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SATURN V LAUNCH OPERATIONS

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## ABSTRACT

This document presents the results of a study conducted under supplemental agreement to NAS8-5608 Schedule III Paragraph 1.9. This supplemental agreement covers the "Study of J-2S Engine Impact on Saturn V Launch Operations" (CCP 272). The study investigates the impact on KSC launch operations of replacing J-2 engines on the S-II and S-IVB stages with J-2S engines.

Processing changes in terms of addition and deletion of operations and manpower for the J-2S vehicle are identified. Requirements to satisfy these processing changes are defined, and conceptual designs for modified equipment are presented. Implementation costs and schedules are contained to assess the total impact on KSC of changing to the new vehicle.

In the performance of this study, vehicle stage data and J-2S engine data were furnished by The Boeing Company Southeast Division, Huntsville; North American Space Division and Rocketdyne Division of North American Rockwell; and McDonnell Douglas Astronautics Company as part of a concurrent study being accomplished under contract to NASA (MSFC).

## KEY WORDS

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Vehicle Processing	J-2S Engine
Interlocks	GSE Conceptual Design
Redlines	Equipment Modifications
Launch Rules	J-2S Implementation Cost
S-IVB	J-2S Implementation Schedule
S-II	Solid Propellant Turbine Starters
Mobile Service Structure (MSS)	Launch Control Center (LCC)
Auxiliary Propulsion System (APS)	Test Control Center (TCC)

ABBREVIATIONS

A	-	Ampere
APS	-	Auxiliary Propulsion System
ASSY	-	Assembly
AUTO	-	Automatic
CDDT	-	Count Down Demonstration Test
CSM	-	Command and Service Module
DDAS	-	Digital Data Acquisition System
DEE	-	Digital Events Evaluator
DI	-	Digital Input
DIST	-	Distributor
DO	-	Digital Output
EBW	-	Exploding Bridge Wire
ECS	-	Environmental Control System
EMER	-	Emergency
ESE	-	Electrical Support System
FAC	-	Facility
FRT	-	Flight Readiness Test
G&C	-	Guidance and Control
GN <sub>2</sub>	-	Gaseous Nitrogen
GSE	-	Ground Support Equipment
HDWR	-	Hardware
He	-	Helium
I. U.	-	Instrumentation Unit
LCC	-	Launch Control Center
LEO	-	Low Earth Orbit
LH <sub>2</sub>	-	Liquid Hydrogen
LM	-	Lunar Module
LOR	-	Lunar Orbit Rendezvous
LOX	-	Liquid Oxygen
L/V	-	Launch Vehicle
MANF	-	Manifold
ML	-	Mobile Launcher
MMH	-	Mono-Methyl-Hydrazine
MSS	-	Mobile Service Structure
N <sub>2</sub> O <sub>4</sub>	-	Nitrogen Tetroxide
N. C.	-	Normally Closed
N. O.	-	Normally Open
NPSH	-	Net Positive Suction Head
OAT	-	Overall Test
O/F	-	Oxidizer to Fuel Ratio
OIS	-	Operational Intercommunication System
OTV	-	Operational Television
P. C.	-	Printed Circuit
PRES	-	Pressure
PSIA	-	Pounds per Square Inch Absolute
PSIG	-	Pounds per Square Inch Gage

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## ABBREVIATIONS (Continued)

P. U.	-	Propellant Utilization
RCS	-	Reaction Control System
RECIRC	-	Recirculation
REG	-	Regulator
S-IC	-	Saturn V First Stage
S-II	-	Saturn V Second Stage
S-IVB	-	Saturn V Third Stage
S&A	-	Safing and Arming
SOL	-	Solenoid
SPTS	-	Solid Propellant Turbine Starter
SSB	-	Single Sideband
SUP	-	Supply
S/V	-	Space Vehicle
SW	-	Switch
SYS	-	System
TCC	-	Test Control Center
TEMP	-	Temperature
VAB	-	Vehicle Assembly Building
VDC	-	Volts, Direct Current
XDCR	-	Transducer

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## 1.0

INTRODUCTION

NASA has allocated R&D funds for studies to evaluate launch vehicle and propulsion programs in terms of cost reduction, greater simplicity, reliability, and payload capability. One phase of these studies, currently funded by Marshall Space Flight Center (MSFC) No. NAS8-5608 Schedule II Part VII Task 3.0, involves replacing J-2 engines on the S-II and S-IVB stages with J-2S engines currently under development by the Rocketdyne Division of North American Rockwell. The results of this study are reported in Boeing documents D5-15772-1 through D5-15772-8. A study of the impact of J-2S equipped S-II and S-IVB stages on KSC was conducted under Contract NAS8-5608 Schedule III Item 1.9, CCP 272 and the results are reported in this document. This study covers all LC-39 support functions and equipment at KSC related to the Apollo programs.

The purpose of this study was to identify the changes in vehicle processing, mission rules, and system interlocks; to establish system requirements leading to conceptual designs of the changed equipment; to determine the KSC schedule flow time for accomplishing the changes; and to determine costs associated with implementing changes and conducting the modified processing. Costs were developed based on the KSC implementation schedule and an MSFC delivery schedule for the S-II and S-IVB stages incorporating the J-2S engine.

The study approach used the AS-503 configuration and processing flow as a baseline. Processing requirements for vehicles using the J-2S modified stages were identified and compared to AS-503 to establish a delta change in vehicle processing, launch rules, and interlock requirements.

Requirements change sheets were then prepared to identify GSE and associated procedures that must be changed to support the delta change items. The changes for each hardware item were collected and a conceptual design for modifying the item was prepared.

The ground rules used in this study are:

- a. Since stages may either be retrofitted from J-2 to J-2S configuration or may be manufactured to the J-2S configuration, this study was based on:
  1. AS-518 vehicle will be the first in-line J-2S modified vehicle

## 1.0 (Continued)

2. AS-508 through AS-515 vehicles will be candidates for retrofit
  3. Once a J-2S vehicle, in-line or retrofit, is received at KSC, all subsequent vehicles will have J-2S engines.
- b. J-2S stage configurations considered in this study are:
1. S-II with no restart capability
  2. S-II with one restart capability
  3. S-IVB with one restart capability
  4. S-IVB with two restarts capability
- c. Throughout this document, references to mission relate to the following stage combinations:
1. Lunar Orbit Rendezvous (LOR) Mission - This mission requires a vehicle configuration composed of an S-IVB with one restart and an S-II with no restarts. The vehicle changes will be limited to the addition of J-2S engines only.
  2. Low Earth Orbit (LEO) Mission - This mission requires a vehicle configuration composed of an S-II with one restart and no S-IVB. This vehicle change will be a result of both J-2S addition and mission requirements.
  3. Synchronous Mission - This mission requires a vehicle configuration composed of an S-IVB with two restarts and an S-II with no restarts. This configuration will be a result of the addition of J-2S engines and mission requirements.

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## 2.0

STUDY OBJECTIVES

The primary study objective was to assess the impact on KSC Saturn V launch operation of replacing the J-2 equipped S-II and S-IVB stages with J-2S equipped stages. Specifically, the objectives of this study were to:

- a. Identify the changes to KSC launch operations resulting from the change to the J-2S engine and associated mandatory stage changes.
- b. Identify the changes to KSC ground equipment and facilities required by the new engine and associated stage changes.
- c. Provide a conceptual design for all new and modified equipment.
- d. Provide an implementation schedule to reflect the time required to design, modify and activate the launch facility for the J-2S vehicles.
- e. Provide cost data for recurring and non-recurring costs. Recurring costs will provide an estimate of the net change in operating costs between J-2 and J-2S vehicles. Non-recurring costs will provide the cost to design, modify and activate the launch facility for the J-2S vehicles.

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**3.0 SUMMARY****3.1 PROCESSING OPERATIONS**

The impact on processing operations primarily concerns modifications to existing operations rather than the addition or deletion of a large number of operations. There were 133 S-II and S-IVB operations identified for the AS-503 baseline vehicle which will be affected by an engine change. For a vehicle configured for a LOR or Synchronous mission, 70 percent of these operations will be reduced by an average of 7 percent and only 2 operations will be deleted. For a vehicle configured for a LEO mission 45 percent of the operations will be reduced by an average of 7 percent, 8 operations will be added due to S-II Auxiliary Propulsion System (APS) and Solid Propellant Turbine Starter (SPTS) and 40 percent of the operations will not be applicable because there will not be an S-IVB stage for this mission.

**3.2 FACILITY AND GROUND SUPPORT EQUIPMENT**

The primary effect of J-2S engines on Facilities and Ground Support Equipment located at KSC will be in the Pneumatic Systems on the Mobile Launcher (ML) and the Control and Monitor panels in the Launch Control Center (LCC) for both LOR and LEO Missions. APS servicing equipment for the S-II will be required on the Mobile Service Structure (MSS) for the LEO Mission only. The changes to the S-II Pneumatic Systems will be the deletion of one console, modification of three consoles, and the modification of ML plumbing and umbilical. The S-IVB Pneumatic System will be changed by the deletion of one console, modification of two consoles, and the modifications to ML plumbing and umbilical. New APS servicing equipment will have to be added to Platform 1 and the 133-foot level of the MSS which will consist of two control assemblies, two valve isolation boxes, and a nitrogen purge system.

**3.3 INTERLOCK SYSTEM**

Changing to J-2S engines impose modified requirements on the Interlock System which will result in the deletion of 54 interlocks for a LOR or Synchronous mission, and the deletion of approximately 34 interlocks on the S-II and the addition of four top level interlocks for APS, Propellant Settling System and the Auxiliary Hydraulic System for a LEO

**3.3 (Continued)**

mission. All S-IVB related interlocks will be deactivated for a LEO mission.

**3.4 REDLINE PARAMETERS**

The LOR mission effect on the Redline Parameters to be monitored will consist of deleting 20 of the original 75 redlines and adding five new redlines. The LEO mission effect will consist of deleting 15 of the original 42 S-II redlines and adding 11 new redlines.

**3.5 OPERATIONS IMPROVEMENT**

It is anticipated that KSC will realize improvements in GSE reliability, processing flow times and launch complex flexibility as a result of the KSC changes which will be made to accommodate the S-II and S-IVB stages with J-2S engines. The overall reliability of the pneumatic systems will improve due to the deletion of consoles and the reduction of complexity of other consoles. Servicing time will be reduced by the elimination of potential leakage points. It is also estimated that the processing flow time will be reduced by approximately 10 percent due to the procedural changes which will be made for processing the J-2S equipped stages. Increased launch complex flexibility will be provided at KSC in that the design changes outlined in this report allow for launching different vehicles of various configurations and mission objectives such as a three stage LOR mission and a two stage LEO mission.

**3.6 SCHEDULE**

The schedules for accomplishing the modification to KSC facilities were drawn considering only modifying and activating one VAB High Bay, one Firing Room and associated equipment, one Mobile Launcher, one MSS, and one Pad. The anticipated date for the establishment of interfaces was used for GSE design start. Modification completion date was established as the date when the first modified stage will be on dock at KSC. These ground rules result in a total of 24 months to accomplish the changes. Of this total time span, 17 months have been allocated for design, 6 months for procurement, and 3 months for modification and activation.

**3.7 COST IMPACT**

Total implementation costs for the LOR concept will be approxi-

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(Continued)

mately \$821,000. The cost for the LEO concept will be approximately \$776,000 (assuming no previous LOR changes). The cost of a LEO concept if LOR changes have previously been incorporated will be \$344,000 based on S-II changes only. These costs represent total design, modification/fabrication and activation manhours and materials. The cost of implementing changes to support the Synchronous mission will be essentially the same as for the LOR mission.

The total operations costs will be reduced from the AS-503 baseline by 3,552 manhours and 3.70 men (crew size) for the LOR mission and 2,238 manhours and 2.33 men (crew size) for the LEO mission.

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## 4.0 J-2S ENGINE DESCRIPTION

### 4.1 GENERAL

The J-2S engine is a simplified version of the present J-2 engine. The engine envelope is identical to and interchangeable with the J-2 engine. The simplification features consist of tap-off turbine drive, elimination of thrust chamber preconditioning and insulation, and multiple start capability using Solid Propellant Turbine Starters. The J-2S engine can run to LOX depletion. It can function in a low thrust idle mode for propellant settling and vehicle maneuvering. The mainstage thrust of the J-2S is approximately 265,000 pounds.

### 4.2 J-2S/J-2 CONFIGURATION DIFFERENCES

The following configuration differences were used as the basis for the analysis presented in subsequent paragraphs of this document.

- a. Deletion of start tank system.
- b. Addition of Solid Propellant Turbine Start (SPTS) with up to three start capability.
- c. Deletion of Recirculation System
- d. Deletion of chilldown requirements.
- e. Provide zero NPSH capability.
- f. Provide capability for idle mode operation.
- g. Add requirement for LOX Dome Purge.
- h. Cryogenic He purge of the thrust chamber is replaced by ambient He purge.
- i. Engine pump purge is required prior to liftoff only.
- j. Delete the Gas Generator System.

## 5.0 STAGE AND VEHICLE CHANGES

### 5.1 GENERAL

This section describes the stage and vehicle configurations selected for study to assess the impact on launch operations at KSC. The detailed engine changes identified in Section 4.0 require stage modifications as described in 5.2. These engine/stage modifications provide capability for various missions depending on the vehicle configuration. Three vehicle configurations were selected for this study as described in 5.3.

### 5.2 STAGE CHANGES

#### 5.2.1 S-II With No Restart Capability - LOR Mission

The S-II stage configuration will be modified to reflect the installation of five J-2S engines. This stage configuration will be used for the LOR or Synchronous Mission vehicle described in 5.3 and 5.3.2. This requires changes to the stage as follows:

- a. The Propellant Recirculation/Chilldown System will be deleted. This includes recirculation pumps, discharge valves, discharge lines, return lines, the helium injection system and all associated electrical and pneumatic control and monitor equipment.
- b. A Fuel Feedline Purge System will be added that will consist of a circular manifold that connects to each engine fuel feedline and will terminate at an umbilical disconnect.
- c. The Propellant Management System will be modified to initiate all engine cutoff at LOX exhaustion. The present LOX Depletion Cutoff System will remain intact but will be disconnected from the engine cutoff circuit and used to supply an arming signal to the main stage OK pressure switch engine cutoff circuit.
- d. The LOX Tank Flight Pressurant System will be modified to operate at a heat exchanger outlet pressure of 1700 PSIA and the pressurant line from the center engine heat exchanger will be deleted. The stage lines will require orifices and the lines will require testing at higher pressures.
- e. The Valve Actuation System will be modified to provide prevalve actuation only which will reduce the stage bottle pressure from 3000 to 725 PSIG and the helium injection system disconnect will be used rather than the present valve actuation system disconnect.

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## 5.2.1 (Continued)

- f. The Hydrogen Tank Pressurant System will be modified for a hydrogen pressurant tap-off pressure of 1300 PSIA which will require orifices in the stage lines and testing at higher pressures.
- g. All ullage motors and their associated ordnance and electrical control will be deleted.
- h. The Start Tank Fill and Vent Control Subsystems will be deleted.
- i. The Start Tank Vent and Relief Subsystems will be retained and used as the Fuel Pump Drain System.
- j. The thrust chamber chill function will be deleted which will change the identification of interfaces on the stage. The thrust chamber purge function will be retained.
- k. The Turbo Pump Purge System will be reidentified as the LOX Dome Purge System.
- l. A new Turbo Pump Purge will be provided by using the present Thrust Chamber Purge System.
- m. The Mainstage OK Pressure Switch checkout pressure will be increased from 500 PSIG to 700 PSIG.
- n. The Solid Propellant Turbine Starters will require electrical power and control from the main stage electrical system.
- o. The Engine Gas Generator System will be deleted which will lead to the deletion of related stage measurements.
- p. The Electrical System will be modified to reflect the above changes.
- q. The Measurement System will be modified to reflect the above changes.

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5.2.2 S-II With One Restart Capability - LEO Mission

The S-II stage configuration will be modified to reflect the installation of five J-2S engines, an Auxiliary Propulsion System, modified Thrust Vector Control, and an LH<sub>2</sub> Tank Balanced Vent System. These require changes to the stage as described in 5.2.1 above

## 5.2.2 (Continued)

and the additional changes described below.

- a. Two McDonnell Douglas Company S-IVB APS modules will be added to the S-II stage. This addition includes a Pressurization Purge System, Propellant Feed System, and three 150 pound thrust engines, and the associated pneumatic and electrical control subsystems.
- b. A Propellant Settling Thrust System (Balanced Vent) will be added. This consists of two axially directed balanced nozzles mounted on the stage external skin which are supplied gas from the LH<sub>2</sub> tank ullage, a Helium Purge System, and associated pneumatic and electrical control subsystems.
- c. The Thrust Vector Control System will be modified to operate during idle mode which will require the addition of four DC powered auxiliary motor pumps, two air systems (tanks, lines and valves) and two 56-volt batteries.
- d. Three LOX pump seal drain vents will be relocated because of the APS system.
- e. The Engine Cutoff System will be modified to provide three cut-off commands.
- f. The Electrical System will be modified to reflect the above changes.
- g. The Measurement System will be modified to reflect the above changes.

5.2.3 S-IVB With One Restart Capability - LOR Mission

The S-IVB stage configuration will be modified to reflect the installation of one J-2S engine. This requires changes to the stage systems as described in 5.2.1 except that 5.2.1(b) through (e) and (i) will not apply and the following additional changes will be required:

- a. The LOX Depletion Cutoff System will be deleted including the sensors and associated electrical control and monitor equipment.
- b. The Propellant Line Prevalves and associated control and monitor equipment will be deleted.

## 5.2.3 (Continued)

- c. The APS ullage engines and their associated control and monitor equipment will be deleted.
- d. Ambient temperature helium will be used for propellant tank pre-pressurization and helium bottle filling.

5.2.4 S-IVB With Two Restarts Capability - Synchronous Mission

The S-IVB stage configuration will be modified to reflect the installation of one J-2S engine, three burn capability and extended stage life. These require changes to the stage as described in 5.2.3 and as noted below.

- a. Additional measurements capability will be provided.
- b. The Auxiliary Hydraulic System will be operated for extended periods of time.
- c. The propellant tank will require one additional repressurization cycle which will change the number of stage helium bottles.

## 5.3 VEHICLE DESCRIPTION

5.3.1 Three Stage LOR Mission Vehicle

The LOR Mission vehicle is a modification of the basic Saturn V vehicle as developed for the lunar landing mission. The vehicle consists of the S-IC stage, S-II stage, S-IVB stage, I.U. and Apollo spacecraft payload. The S-II and S-IVB stages will use J-2S engines and the stage systems will be modified to the extent required for replacement of J-2 engines with J-2S engines. This vehicle will be capable of placing a payload in an earth parking orbit and then boosting the payload to escape velocity by a single restart of the S-IVB stage.

5.3.2 Three Stage Synchronous Mission Vehicle

The Synchronous Mission vehicle is a modification of the three stage LOR mission vehicle. The S-IC and S-II stages are identical to those of the LOR Mission vehicle. The modifications to the S-IVB stage will be three burn capability and extended stage life due to the flight time of the Synchronous Orbit Mission. This vehicle will

## 5.3.2 (Continued)

be capable of placing a payload in synchronous earth orbit by placing the payload in a parking orbit, boosting it to the synchronous orbit velocity using an S-IVB restart and finally circularizing the payload in synchronous orbit with a second S-IVB restart.

5.3.3 Two Stage Low Earth Orbit Mission Vehicle

The Low Earth Orbit Mission (LEO) vehicle is a two stage S-IC/S-II configuration using a "S-IVB Workshop" Apollo payload with the I. U. located between the S-IVB Workshop and the Apollo spacecraft. The S-II will have system modifications for operation during the coast to orbit period. A continuous Propellant Vent System and Attitude Control Auxiliary Propulsion System will be provided. This vehicle will be capable of placing the payload in low earth orbit using a single restart of the S-II stage to circularize the orbit.

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## 6.0 LAUNCH OPERATIONS CHANGES

### 6.1 PROCESSING CHANGES

The AS-503 vehicle was the baseline processing flow against which changes were measured. Each function, starting with Low Bay preparations to receive a stage through to vehicle launch and post launch refurbishment, was analyzed to determine whether it would be affected by the J-2S configured stage or vehicle. The results of this analysis are summarized and presented in Appendix A.

There have been 133 processing functions identified for the AS-503 vehicle. For the LOR and Synchronous missions, 98 functions would be changed, 2 functions related to recirculation/chilldown would be deleted, and the balance would be unaffected. For the LEO mission, 60 functions would be changed, 55 functions related to the S-IVB stage would not apply, 1 function related to recirculation would be deleted, 8 functions would be added, and the remainder would be unaffected. Of the 8 new functions, 6 would be related to the S-II APS, 1 to the IU/S-II mating and 1 to the IU/Space Station mating.

A review of procedures for accomplishing the processing functions indicated that the average procedure change resulted in an approximate 7 percent reduction in manhours. Since many LOR and Synchronous mission processing functions were not affected, the net impact on processing manhours for these vehicles is very small. For the LEO mission, while the S-II processing manhours were slightly increased due to the addition of new functions, the elimination of the S-IVB stage resulted in a large decrease of processing time.

Vehicle processing changes that are unique to the vehicle configurations are discussed in Sections 6.1 through 6.1.3. Section 6.2 defines the impact of the J-2S engine on the Launch Mission Rules. This impact is primarily one of changing S-II and S-IVB stage redlines. Section 6.3 covers changes to the interlock system resulting from stage changes related to the J-2S engine.

#### 6.1.1 Three Stage LOR Vehicle (Baseline)

The processing changes related to this vehicle will be as follows:

- a. Installation and checkout of ullage rockets will be deleted for both the S-II and S-IVB stages

**6.1.1 (Continued)**

- b. Test and checkout of recirculation and engine chilldown will be deleted for both stages.
- c. Checkout of the S-IVB APS ullage engine will be deleted.
- d. Test and checkout of the engine startup provision and checkout of engine startup sequence will be modified for both stages. Start tank and gas generator functions will be deleted and Solid Propellant Turbine Starters (SPTS) and LOX dome purge functions will be added.
- e. Test and checkout of the S-IVB prevalues and LOX depletion sensors will be deleted. In the case of the S-II stage, the processing related to prevalues and LOX depletion sensors will be modified to provide cutoff for all engines.
- f. Installation and checkout of flight batteries will be modified to reflect deletion of two of the S-II batteries and the replacement of one of the S-IVB batteries with a smaller battery.
- g. Test and checkout of the engine idle mode will be added and test and checkout of the hydraulic actuation will be modified for the S-IVB.

**6.1.2 Three Stage Synchronous Orbit Vehicle**

The additional processing changes will be as follows:

- a. Test, checkout, and ordnance installation for the SPTS will be added to the S-IVB stage.
- b. Telemetry test and checkout will be modified to account for measurements from the S-IVB and IU. The change to the S-IVB will include adding signal conditioning racks, multiplexers and a new tape recorder to handle the additional measurements and adding a power amplifier to transmit them the additional distance. The IU has a modification to its power amplifiers.
- c. Installation and checkout for increased battery capacity will be added to the S-IVB and IU. For the S-IVB, two electrical isolation switches will be added to prevent the two batteries from bucking each other during ground operations.

### 6.1.3 Two Stage LEO Vehicle

The processing changes related to this vehicle will be as follows:

- a. All S-IVB processing will be deleted.
- b. All processing changes for the S-II identified in Section 6.1.1 for the LOR vehicle will apply to the LEO mission.
- c. Installation, test, checkout, servicing, and gas removal for an APS system will be added to the S-II stage. The APS system will be identical to the LOR APS system used on the S-IVB stage.
- d. Test and checkout of a balanced propulsion venting of the LH<sub>2</sub> tanks will be added to the S-II stage. This system will provide positive oxidizer and fuel settling for the S-II stage.
- e. Test and checkout for an auxiliary hydraulic system including installation of hydraulic system batteries and servicing of hydraulic system air cabling supply will be added to the S-II stage.

### 6.2 LAUNCH RULES

Launch Mission Rules are developed to provide guidance to the Launch Director and launch team organization by specifying pre-planned decisions which are designed to minimize real time rationalization required when non-nominal situations occur during the launch countdown and applicable prelaunch tests. The AS-503 Launch Mission Rules were reviewed to determine if the replacement of J-2 engines by J-2S engines would change the Launch Mission Rules. Only mandatory redlines were considered in the review, and it was assumed that all AS-503 mandatory redlines would be available for stages equipped with J-2S engines except for systems which were deleted on J-2S engines. A detailed listing of the redline differences is included in Appendix D of this document. The following changes to the AS-503 Launch Mission Rules document will be required:

- a. Section II "Launch Vehicle Operations"
  1. Delete 15 of 42 mandatory redline measurements and add 4 new mandatory redline measurements for S-II with no restarts.

## 6.2 (Continued)

2. Delete 15 of 42 mandatory redline measurements and add 11 mandatory redline measurements for S-II with one restart.
  3. Delete 5 of 32 mandatory redlines and add 1 mandatory redline for the S-IVB.
- b. Section IV "Technical Support Operations" will require deletion of measurement item 4-418.

In summary, it appears that the probability of meeting preplanned launch windows will be increased due to the reduced number of redlines; however, since launch mission rules must be prepared for each missile to be fired and since the impact of J-2S engines on the launch mission rules is small, the impact on KSC costs or schedules is considered negligible.

## 6.3 INTERLOCKS

The Saturn V Interlock System consists of relay logic circuits which react to timed commands from the Terminal Countdown Sequencer. The relay logic circuits issue the commands to the electromechanical components on each of the launch vehicle stages and ground support equipment and respond to the vehicle condition established by the command to set up an interlock condition which allows the next event in the countdown to be completed. Only launch critical functions and conditions are interlocked as prerequisites for a safe launch and the accomplishment of the primary mission objectives.

The present Saturn V Interlock System as defined in Boeing Document D5-16266-4, "Functional Analysis Document for Saturn V Interlock System," was reviewed to determine the impact resulting from the use of J-2S engines on the S-II and S-IVB stages as defined in Boeing Document D5-15772-2, "J-2S Improvement Study" (draft) and the changes in missions as defined in Section 5.0.

The detailed results of this review are tabulated and shown schematically in Appendix C. These results indicate that approximately 54 interlocks can be deleted from the system for a LOR or Synchronous mission. These deletions result from the use of J-2S engines on the S-II and S-IVB stages which are the only changes to the vehicle configuration for these missions. The interlock deletions are associated with Recirculation System, Ullage Systems, Gas

## 6.3 (Continued)

**Generator, Prevalves, and LOX Depletion Cutoff System.** The impact of a LEO mission will result in the deletion of the interlocks associated with the use of J-2S engines on the S-II (approximately 34), the deletion of all S-IVB related interlocks (approximately 45 top level interlocks), and the addition of S-II interlocks (four top level) due to the addition of APS Propellant Settling System and the Auxiliary Hydraulic System for thrust vector control during idle mode.

The hardware changes associated with the Interlock System are contained in the Electrical System changes identified in Section 7.5.

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7.0

## FACILITY AND EQUIPMENT MODIFICATIONS

7.1

### GENERAL

This section includes the results of the facility and equipment requirement development and conceptual design. Requirement Change Sheets which were the end product of the facility and equipment requirement development were previously submitted and are included in Appendix D. A summary of this effort is included in Paragraph 7.2 of this document. Paragraphs 7.3 through 7.5 contain the results of the conceptual design. The major changes to KSC hardware resulting from this effort are in the GSE Pneumatic System, the Control and Monitor Panels in the LCC, and the addition of APS servicing equipment for the S-II Stage.

7.2

### REQUIREMENT CHANGE SHEETS

Requirements were developed based on a study of McDonnell Douglas, Rocketdyne, and North American Rockwell stage and engine data and based on the vehicle processing data included in Appendix A of this document. These requirements were then packaged on Requirement Change Sheets for each of the following 15 systems:

- a. S-II APS
- b. S-IVB APS
- c. Recirculation Chilldown System
- d. Ullage Rocket System
- e. Electric Power
- f. Flight Control System (S-II and S-IVB)
- g. Pneumatic Control and Purge System
- h. Environmental Control System
- i. Electrical Control System
- j. Instrumentation and Telemetry System
- k. LOX and LH<sub>2</sub> Pressurization System
- l. IU System
- m. Gas Generator System
- n. Engine Start System
- o. J-2S Engine

A review of all AS-503 procedures was made to determine which procedures were impacted by each new requirement and the affected procedures were tabulated on the Requirement Change Sheet for each of the above 15 systems. A review of existing schematics was then performed to identify the GSE/Facility items which require change and these were tabulated on the Requirement Change Sheet. Results

## 7.2 (Continued)

of this effort are included in Appendix D of this document.

## 7.3 PNEUMATICS

The specific requirements imposed on the GSE Pneumatic Systems by the replacement of J-2 engines with J-2S engines are defined in Requirements Sheet 7.0 in Appendix D of this document. The changes to the Pneumatic Systems are shown in Figure 7-1 through Figure 7-5. Descriptions of these changes are tabulated in Table 7-1. The changes in the Pneumatic Systems are based on the design concept that: 1) consoles which are no longer required will be removed rather than deactivated, and 2) S-II Pneumatic System consoles and associated plumbing will be modified to provide the capability to support either a LEO or LOR mission without further modification.

A summary of the Pneumatic System changes presented in Table 7-1 is presented as follows:

- a. S7-41A "S-II Regulation and Distribution Console"
  - 1. Add 32 new components plus interconnecting wiring and plumbing
  - 2. Modify or recalibrate 10 components
  - 3. Delete 17 components plus interconnecting wiring and plumbing.
- b. S7-41B "S-II Pneumatic Control Console"
  - 1. Add 20 new components plus interconnecting wiring and plumbing
  - 2. Modify or recalibrate one pressure transducer
  - 3. Delete 11 components plus interconnecting wiring and plumbing.

## 7.3 Continued

- c. S7-41C "S-II Pneumatic Actuation, Purge, and Checkout Console"
  - 1. Add 8 components plus interconnecting wiring and plumbing
  - 2. Delete 10 components plus interconnecting wiring and plumbing
- d. S7-41D "S-II GH2 Servicing Console" and associated plumbing, is deleted.
- e. A7-71 "S-II LH<sub>2</sub> Heat Exchanger"
  - a. Disconnect and cap two lines
- f. DSV-4B-432-A-1414 "S-IVB Pneumatic Console"
  - a. Add one solenoid valve and associated wiring and plumbing
- g. DSV-4B-433A-1415 "S-IVB Pneumatic Console"
  - a. Add 25 new components and associated wiring and plumbing
  - b. Delete 61 components and associated interconnecting wiring and plumbing.
- h. Delete the S-IVB Heat Exchanger (DSV-4B-438-A-1416) and its associated plumbing and circuitry.

## 7.4 APS SERVICING SYSTEM MODIFICATIONS

7.4.1 General Requirements and Assumptions

The S-II with one restart and the S-IVB will require APS units (less APS ullage control engines) for attitude control of the stage during flight. The S-II APS units will be identical to the existing S-IVB APS units and will be located on the aft end (Vehicle Station 1760) of the S-II stage. Onboard propellant storage and ullage pressurization systems will be identical to that utilized by the S-IVB APS. GSE units required for servicing the APS units will be the same as are now provided for the S-IVB APS. The hypergolic servicing of either APS system occurs during the Hypergolic Load Test Sequence

## 7.4.1 (Continued)

of the vehicle countdown preparations. Contractors will conduct APS loading for their respective stages.

$\text{GN}_2$  (750 psig) will be provided for the S-IVB APS servicing over Swing Arm No. 6 and  $\text{GN}_2$  (500 psig) will be provided for the S-II APS servicing to Platform No. 1 from S-II Service Arm 4. GHe (3200 psig) for the onboard APS He storage and pressurization will be provided for the S-IVB APS over the umbilical on Service Arm 6. GHe (3200 psig) will be provided to the S-II onboard APS He storage and pressurization over the S-II umbilical on Service Arm 4.

7.4.2 Alternate S-IIS APS Loading Methods

The primary method considered is that of installing the S-IVB Loading System at the S-II level. This will require the installation of two additional isolation valve boxes on the 133-foot level of the MSS similar to APS servicing boxes on the 221-foot level and two control assemblies on Platform No. 1. This approach is shown in plan view on Figure 7-6. The APS fuel and oxidizer systems are shown in Figure 7-7 and 7-8, respectively.

The S-II APS can also be serviced from fuel lines 24-1, 23-1, and 25-1 and oxidizer lines 27-4, 28-4, and 29-5, on Platform No. 2 by teeing off of these lines with shutoff valves and dropping flex lines (approximately 90 feet each) from valves down to Platform No. 1 for loading the S-II APS. The propellant lines, two for oxidizer and two for fuel, will have to be drained into containers and purged following propellant transfer.

A third potential hypergolic loading scheme analyzed in a Boeing study involve S-IVB APS using carry-on canisters (33.3 gallons oxidizer and 33.6 gallons fuel). The results of that study are applicable to the S-II APS since propellant requirements are identical for servicing the S-IVB and S-II APS. With the carry-on system, vent lines (approximately 170 feet each) will have to be run across the 133-foot level and valved into lines 29-0 and 25-0 for oxidizer and fuel.

If a Hypergolic Carry-on System is adopted for loading S-IVB APS, the same carry-on system and procedural methods will be used for transferring hypergolics to the S-II APS.

## 7.4.3

Selected Method

Under present conditions the method that presents the most merit is the installation of two additional isolation boxes and oxidizer and fuel control assemblies on the 133-foot level. The installation of the two additional isolation valves boxes will be as follows: one fuel box for lines 23-0 (fill), 24-0 (return), and 25-0 (vent) and one oxidizer box for lines 27-0 (fill), 28-0 (return), and 29-0 (vent) (See Figure 7-8 and 7-7) on the 133-foot level of the MSS similar to APS servicing boxes on the 221-foot level. Lines (approximately 170 feet each) from the isolation valve boxes will be routed, oxidizer on one side of the MSS and fuel on the other side, along the 133-foot level to interface plates adjacent to MSS Platform No. 1 located at approximately the 135-foot level for propellant loading of the S-II APS. The horizontal pipe chases to the APS interface at Platform No. 1 will maintain a positive slope from the interface plates to insure proper draining of the hypergol lines following propellant transfer. This system is identical to the system that now services the S-IVB APS, and S-II APS propellant loading will be procedurally the same. There will be no special drain or purge requirement as no additional low points will be developed in the propellant delivery and return lines.

The addition of this system at the 133-foot MSS level and on Platform No. 1 will also require the following additions:

- a. Hardline piping (insulated) from the isolation valve boxes along each side of the MSS to a new MMH Bulkhead (Interface Plate) on the fuel side and to a new N<sub>2</sub>O<sub>4</sub> Bulkhead (Interface Plate) on the oxidizer side.
- b. Pipe chases and a catwalk for the hardline piping mentioned above on each side of the MSS.
- c. Flex hoses from the bulkheads to the control assemblies and from the control assemblies to the vehicle APS units.
- d. Four additional OIS boxes and 2 OIS phones on Platform No. 1 to monitor and control hypergol loading.
- e. Relocation of 2 OTV cameras from the S-IVB APS Loading function to the S-II Loading function for the LEO mission only.
- f. GN<sub>2</sub> flex lines from Service Arm 4 to the control assemblies for purging and valve actuation. This system will also require (2) 0-50 PSIG regulators and (1) 0-500 PSIG regulator.

## 7.4.3 (Continued)

- g. Additional safety equipment will have to be installed at the 133-foot level of the MSS. Included in this equipment will be a safety shower, eyewash and a first aid station.
- h. A GN<sub>2</sub> purge capability for the new isolation valve boxes on the MSS. This capability already exists at the spacecraft and S-IVB MSS levels. Therefore, the change is minor and will only require the installation of valves in the GN<sub>2</sub> lines at the 133-foot level and pipe runs to the isolation valve boxes.

The addition of an APS System on the S-II stage will require external vehicle access between station 1760 and 1900 at vehicle positions I and III. MSS Platform 1 positioned at station 1760.00 will satisfy this requirement. 65ICD9144 states that vehicle to MSS Platform 1 compatibility exists between station 1646 and 1920. The hinged clamshell on Platform 1 which closes in the vicinity of Service Arm 4 will have to remain partially open at this position; however, this will not limit the access to the APS System.

## 7.5

**ELECTRICAL/INSTRUMENTATION**

Changes to Electrical and Instrumentation GSE were identified by expanding the Requirement Change Sheets (Section 7.2 of this document) to identify detailed functional changes to the GSE. The results of this phase of the analysis are in Appendix E of this document.

The functional changes were collected by GSE system or item to identify the total change to each. Table 7-2 lists all GSE systems or items that will change to support processing of the J-2S configured stages. Each change is related to the particular stage and stage configuration it supports.

The changes that involve redesignating existing elements to new functions or that add new elements have conceptual design schematics included in this section. See Figures 7-9 through 7-17. Where the change is a simple deletion of an element (switch, patchcord, data channel) the entry in Table 7-2 is sufficient definition of the design concept.

Figures 7-16 and 7-17 show the design concept of adding APS control and monitoring to the S-II stage ESE. While the S-II APS provisions are identical to that of the S-IVB APS, it is necessary to develop the conceptual design to this level to identify all related equipment changes. The gross change to each affected GSE item is accumulated and the total entered on Table 7-2.

7.5

(Continued)

Where Table 7-2 indicates that more patches will be added to a GSE distributor than are deleted, the distributor has sufficient existing spare capacity to absorb the extra additions without a hardware change. The only case where new computer channels will exceed channel deletions is in the case of the DDAS System for the S-II with one restart case. Since all channels allocated to the S-IVB stage will be available in this case, no changes to add extra DDAS capacity will be required.

In the case of the S-II stage with one restart where two new APS panels will be added in the LCC, particular attention is given to related cabling and electrical power capacities. In both cases existing cables and existing electric power service will have adequate capacity to support the new panels.

The general design concept related to the additions shown in Figure 7-9 through 7-17 will be to use existing spare components and cabling whenever possible and where new components are needed will use the same type of components as already in use.

In the case of instrumentation changes, the increased number of telemetry measurements identified for all of the stage configurations are within the capacity of the existing telemetry systems. No new links nor transmission data rates were identified. Where data transmission range is increased, as in the case of the S-IVB with two restarts (synchronous mission), this results in stage changes to transmit more data a greater distance but these changes will not change ground equipment.

The total impact of the changes discussed above and presented in Table 7-2 will be a small reduction in hardware and processing for each vehicle except for the case of the LEO mission where the elimination of the S-IVB stage will result in a major reduction in processing.

7.6

## HANDLING AND ACCESS EQUIPMENT

7.6.1

### A7-84 Heat Shield Platform

Use of the J-2S engine will require that the present heat shield be reduced in size. Approximately three inches will be cut away from the shield in the engine nozzle area and the support struts will be relocated. These changes will require fabrication of a new heat shield platform. This platform is installed during vehicle checkout to provide a walkway for personnel to service the S-II stage. The

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## 7.6.1 (Continued)

platform consists of a one-inch thick, aluminum skin, honeycomb interior structure support by four-inch thick styrofoam blocks.

In order to conform to the reduced size of the heat shield, the platform will have to be cut to allow new struts to pass through the structure (there are four new strut points called for in the changed heat shield). In addition, a kickplate approximately one-inch high will be needed around the circumference of the platform.

7.6.2 SDD-259 LOX Tank Internal Access Platform Outer Stand

A slosh baffle will be installed in the aft end of the S-II LOX tank. This baffle consists of a 24-inch wide conical ring perpendicular to the tank wall. This baffle will interfere with the strut of the outer stand SDD-259 as shown in Figure 7-18.

The strut will be cut and lengthened so as to clear the top of the baffle. It will be welded at the break point.

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TABLE 7.1  
S-II REGULATION AND DISTRIBUTION CONSOLE

## S7-41 Section A

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION
7.1	<p>For the He to be provided to S7-41 Section C, the following components and connecting plumbing must be added per schematic to S7-41 Section A:</p> <p>Manual Regulator            Solenoid Valve N.O.            Relief Valve (2)            Dome Loaded Regulator            Pressure Gage            Calibration Valve            Pressure Switch</p>
7.2	<p>For the He to be provided to S7-41 Section B, the following components in S7-41 Section A must be adjusted or altered:</p> <p>Manual Regulator A9015            Dome Loaded Regulator A8997            Pressure Switch A8998            Relief Valve A9001            Manual Regulator A9003            Dome Loaded Regulator A9004</p>
7.3	Reroute Airborne LOX Fill Line supply line in S7-41 Section A as shown on schematic.
7.6	<p>Delete lines and components per schematic.</p> <p>For the He to be provided to S7-41 Section B, the following components and connecting plumbing must be added per schematic to S7-41 Section A:</p> <p>Manual Regulator            Solenoid Valve N.O.            Dome Loaded Regulator            Relief Valve (2)            Pressure Gage            Calibration Valve            Pressure Switch</p>

S-II REGULATION AND DISTRIBUTION CONSOLE  
TABLE 7.1

## S7-41 Section A

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION								
7.8	<p>For the <math>\text{GN}_2</math> to be provided to S7-41 Section B, the following components and connecting plumbing must be added per schematic to S7-41 Section A:</p> <p>Manual Regulator Solenoid Valve N.O. Dome Loaded Regulator Relief Valve (2) Pressure Gage Calibration Valve Pressure Switch</p>								
8.1	<p>For the compressed air to be provided to S7-41 Section B, the following components and connecting plumbing must be added per schematic in and adjacent to S7-41 Section A:</p> <p>Storage Bottle (2) - 50 SCE @ 2200 psig each Manual Shutoff Valve (2) Filter Manual Vent Valve Calibration Pressure Gage</p> <p>In addition, the following components in S7-41 Section A must be adjusted or replaced:</p> <table> <tr> <td>Manual Regulator</td> <td>A15585</td> </tr> <tr> <td>Pressure Gage</td> <td>A15587</td> </tr> <tr> <td>Pressure Switch</td> <td>A15588</td> </tr> <tr> <td>Relief Valve</td> <td>A15584</td> </tr> </table>	Manual Regulator	A15585	Pressure Gage	A15587	Pressure Switch	A15588	Relief Valve	A15584
Manual Regulator	A15585								
Pressure Gage	A15587								
Pressure Switch	A15588								
Relief Valve	A15584								

TABLE 7.1  
S-II PNEUMATIC CONTROL CONSOLE

## S7-41 Section B

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION
7.1	None
7.2	For the He to be provided to the S-II Intermediate Umbilical Plate, the following components in S7-41 Section B will require adjusting or altering:
7.3	Delete lines and components per schematic.
7.6	For the He to be provided to the S-II Intermediate Umbilical Plate, the following components and connecting plumbing must be added per schematic to S7-41 Section B:
7.8	For the He to be provided to the Mobile Service Structure, the following components and connecting plumbing must be added per schematic to S7-41 Section B:

TABL 1.1  
S-II PNEUMATIC CONTROL CONSOLE  
S7-41 Section B

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION
8.1	<p>For the compressed air to be provided across Arm No. 4 to the MSS, the following components and connecting plumbing must be added per schematic to S7-41 Section B:</p> <p>Pressure Gage Manual Vent Valve</p> <p>In addition, the following component in S7-41 Section B must be adjusted or replaced:</p> <p>Pressure Transducer A15596</p>

TABLE 7.1  
S-II PNEUMATIC ACTUATION, PURGE AND CHECKOUT CONSOLE  
S7-41 Section C

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION
7.1	<p>For the He to be provided to the umbilical, the following components and connecting plumbing must be added per schematic to S7-41 Section C:</p> <ul style="list-style-type: none"> <li>3-way Solenoid Valve</li> <li>Check Valve (2)</li> <li>Filter</li> <li>Manual Vent Valve</li> <li>Calibration Valve</li> <li>Pressure Transducer</li> <li>Relief Valve</li> </ul>
7.2	<p>None</p> <p>Delete lines and components per schematic.</p>
7.3	<p>None</p>
7.6	<p>None</p>
7.8	<p>None</p>

TABLE 7.1  
S-II GH<sub>2</sub> SERVICING CONSOLE  
S7-41 Section D

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION
7.3	Remove S7-41 Section D and all associated plumbing since the requirement for GH <sub>2</sub> servicing has been deleted.

TABLE 7.1  
S-II LH<sub>2</sub> HEAT EXCHANGER

A7-71

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION
7.3	<p>Disconnect and cap inlet and outlet lines for the following two functions:</p> <ul style="list-style-type: none"><li>- Engine Thrust Chamber Chilldown Circuit</li><li>- Turbine Start Bottle Purge and Chilldown Pressurization Circuit</li></ul>

TABLE 7.1

S-IVB PNEUMATIC CONSOLE  
DSV-4B-432-A-1414

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION
7.12	For the He to be provided to DSV-4B-433-A-1415, the following component and connecting plumbing must be added per schematic to DSV-4B-432-A-1414:
7.13	None
7.14	None

TABLE 7.1  
S-IVB PNEUMATIC CONSOLE  
DSV-4B-433-A-1415

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION
7.12	<p>For the He to be provided to the Stage Umbilical, the following components and connecting plumbing must be added per schematic to DSV-4B-433-A-1415:</p> <p>Manual Regulator            Solenoid Valve N.O.            Dome Loaded Regulator            Relief Valve (2)            Check Valve (2)            3-way Solenoid Valve            Filter            Manual Vent Valve            Calibration Valve (2)            Pressure Gage            Pressure-e Switch            Pressure Transducer</p>
7.13	<p>For the He to be provided to the Thrust Chamber Jacket, the orifice A11937 located in DSV-4B-433-A-1415 must be replaced with a manual regulator. In addition, the following component and connecting plumbing must be installed per schematic to DSV-4B-433-A-1415:</p> <p>Relief Valve</p>
7.14	<p>Delete Engine Control Bottle Supply Line, associated components and plumbing per schematic.</p>

TABLE 7.1

S-IVB PNEUMATIC CONSOLE  
DSV-4B-433-A-1415

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION
11.1 Modify the S-IVB Pneumatic Console to provide ambient He for fuel tank prepressurization supply by adding the following:	<p>Solenoid Valve (1)      Check Valve (1)      Orifice (1)      Calibration Valves (2)      Filter (1)      Pressure Transducer (1)      Pressure Indicator (1)      Interconnecting Plumbing and Fittings</p>

TABLE /1  
S-IVB HEAT EXCHANGER  
DSV-4B-438-A-1416

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION
7.12	None
7.13	Delete and reroute plumbing per schematic.
7.14	Delete heat exchanger and associated plumbing. Reroute or cap plumbing per schematic.

TABL( .1  
S-IVB UMBILICALS

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION
7.12	Add umbilical interfaces and connecting plumbing to route gas from DSV-4B-433-A-1415 for the following new function:  LOX Dome Purge (475 ± 25 psig Helium)
7.14	Delete or cap plumbing and umbilical interface for the following deleted functions:  Turbine Start Bottle Supply (1500 psig Hydrogen gas)
7.14	Fuel Tank Prepressurization (3000 psig Helium)

TABLE / .1  
S-II UMBILICALS

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION
	Add umbilical interfaces and connecting plumbing to route gas from S7-41 Section B and C for the following new functions: LOX Dome Purge ( $475 \pm 25$ psig Helium) S-II APS Helium Storage Tank (3000 psig Helium) Fuel and Oxidizer Purge to MSS (0-500 psig GN <sub>2</sub> ) Delete or cap plumbing and umbilical interface for the following deleted functions: Engine Helium Bottle Purge Pressurization and Prepressurization (3250 psig Helium) Turbine Start Bottle GH <sub>2</sub> Vent Control Pressure (420 psig Helium) Recirc. Bottle Helium Supply Disconnect Valve Actuation Pressure (750 psig Helium) Turbine Start Bottle Purge, Chilldown and Pressurization (1175 psig Hydrogen gas)
7.1	
7.6	
7.8	
7.3	
7.3	
- 7.3	
7.3	

TABLE 7.1  
S-II UMBILICAL

REQUIREMENT SHEET NO.	GSE/FSE CHANGE DESCRIPTION
8.1	Add umbilical interface and connecting plumbing to route air from S7-41 Section B across Arm No. 4 for the Air Supply to TVC Motor Function ( $470 \pm 45$ compressed air).

TABLE 7.2 - ELECTRICAL CHANGES

GSE Item	USED ON:				Modification
	S-I I., No Restart	S-II, One Restart	S-IVB, One Restart	S-IVB, Two Restarts	
<u>S-IVB LCC ESE</u>					Re-identify DS28 (Fig. 7-9) Delete DS18, DS20, DS27, DS29, DS31 Delete entire panel
601-405A1 - Networks Panel	x		x	x	Delete S17 Delete DS10, DS14
601-406A1 - Recirculation Panel	x		x	x	Delete M7, M8 Delete S11, S16, Delete DS23, DS26, DS27, DS29
601-406A3 - Helium Control Panel	x		x	x	Re-identify DS69 (Fig. 7-10) Delete S14, S40 Delete DS16, DS17, DS22, DS24, DS25, DS30, DS32, DS34, DS36, DS38, DS40, DS72
601-406A4 - GH/GN Control Panel	x		x	x	Delete M1, M2, M3, M4, M5, M6 Delete S6, S7, S8, S13 Delete DS6, DS7, DS8, DS14, DS15, DS16, DS17, DS21, DS27
601-406A5 - Engine Test Panel	x		x	x	Re-identify DS2, DS3, DS4, DS5, DS6, DS7 (Fig. 7-9,-11, -12) Delete S3 Delete M3, M4
601-409A1 - EBW & Ordnance Panel	x	x	x	x	Add 1 indicators (Fig. 7-11) Add 4 indicators (Fig. 7-11, -12)

TABLE 7.2 - ELECTRICAL CHANGES

GSE Item	USED ON:			Modification
	S-II, No Restart	S-II, One Restart	S-IVB, One Restart	
S-IVB Events Display Panel			x	x Delete 18 indicators
601-419A1 - S-IVB APS Launch and Monitor Pnl		x	x	Delete DS7
601-420A1 - LCC Patch Distributor		x	x	Add 2 patchcords Delete 23 patchcords De-activate K1122, K1123 Add 4 patchcords
601-421A1 - LCC Patch Distributor		x	x	Delete 108 patches De-activate K1117, K1118, K1119, K1120, K1121, K1124
601-1121A1 - LCC Patch Distributor		x	x	Delete 3 patches
5975 S-IVB Measurement Rack			x	Delete 9 measurements
<u>S-IVB ML ESE</u>			x	
202-423A1 - ML S-IVB Patch Distributor		x		Delete B202-423A2 Re-identify K54 Add 4 patches Delete 23 patches De-activate K623, K627, K645, K634, K635, K622, K626, K628, K629, K630, K631, K632, K633, K638, K639, K646
6221 ML S-IVB Crossover Distributor		x	x	Add 4 patches Delete 20 patches

TABLE 7.2 - ELECTRICAL CHANGES

GSE Item	USED ON:			Modification	
	S-II, No Restart	S-II, One Restart	S-IVB, One Restart	S-IVB, Two Restarts	
202-420A1 ML S-IVB Patch Distributors			x	x	Re-identify K54 Delete 7 patches De-activate K59, K60, K634, K635 K632, K633
202-421A1 ML S-IVB Patch Distributor			x	x	Delete 27 patches De-activate K288, K254, K351, K266, K249, K232
6261 ML S-IVB Crossover Distributor			x	x	Delete 32 patches
202-422A1 ML S-IVB Patch Distributor			x	x	Delete 30 patches De-activate K464, K415, K419, K414, K413, K424, K425, K635
202-424A1 ML S-IVB Patch Distributor			x	x	Delete 1 patch De-activate K890
6600 EDV-18 Relay Rack			x	x	Delete 2 patches
<u>GSE SYSTEMS (S-IVB Changes)</u>					
110A Computer	x			x	Add 2 channels
	x			x	Add 4 channels
				x	Re-identify 1 channel
				x	Delete 53 channels
				x	Modify software
DDAS			x		Delete 16 channels
					Modify software

TABLE 7.2 - ELECTRICAL CHANGES

GSE Item	USED ON:			Modification		
	S-II, No Restart	S-II, One Restart	S-IVB, One Restart	S-IVB, Two Restarts		
DEE			x	x	Add 2 channels Delete 21 channels Modify software Modify software	
PTCS			x	x	No new or expanded electric power service identified	
Facility Power			x	x	No new cabling identified Instrumentation Channel re-allocation	
Cross Country Cabling			x	x		
CIF Telemetry & Data Display			x	x		
<u>S-IVB TCC</u>			x	x	Delete 3 indicators & 3 switches (LOX Level Test)	
Propellant Level Monitor Panel			x	x	Delete 2 meters (Start Tank Press & Seal Purge)	
Engine Test Panel			x	x	Re-identify STDV switch to main-stage start solenoid & add indicator	
					Delete 3 switches (Gas Generator & Start Functions)	
					Delete 12 indicators (Start Tank & GG)	

TABLE 7.2 - ELECTRICAL CHANGES

GSE Item	USED ON:			Modification
	S-II, No Restart	S-II, One Restart	S-IVB, One Restart	
Stage Pressure Panel		x	x	Delete prevalve switch Delete chilldown switch Delete 3 indicators (prevalve & chilldown)
802-463A4 - Power Distributor		x	x	Delete approximately 33 patches
802-420A1 - Control Distributor		x	x	Delete approximately 66 patches

TABLE 7-2 - ELECTRICAL CHANGES

GSE Item	USED ON:				Modification
	S-II, No Restart	S-II, One Restart	S-IVB, One Restart	S-IVB, Two Restarts	
601-205A1 - Networks Panel	x	x			Delete S2, S21 Delete DS10, DS20, DS25
601-206A1 - Engine 201 Panel	x	x			Delete S6, S7 Delete DS4, DS12, DS13, DS14, DS15, DS19, DS23
601-206A2 - Engine 202 Panel	x	x	x		Delete S6, S7 Delete DS4, DS12, DS13, DS14, DS15, DS19, DS23
601-206A3 - Engine 203 Panel	x	x	x		Delete S6, S7 Delete DS4, DS12, DS13, DS14, DS15, DS19, DS23
601-206A4 - Engine 204 Panel	x	x	x		Delete S6, S7 Delete DS4, DS12, DS13, DS14, DS15, DS19, DS23
601-206A5 - Engine 205 Panel	x	x	x		Delete M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M13 Delete S3, S4, S5, S6, S7, S8, S9, S11, S13, S14, S15, S16, S17, S18, S19, S20, S21, S22, S23
601-206A6 - A11 Engine Panel	x	x	x		Delete DS4, DS6, DS7, DS8, DS9, DS10

TABLE 7-2 - ELECTRICAL CHANGES

GSE Item	USED ON:				Modification
	S-II, No Restart	S-II, One Restart	S-IVB, One Restart	S-IVB, Two Restarts	
601-206A10 - Pneumatics Panel	x	x			Delete S3, S35, S36 Delete DS2, DS8, DS60, DS61 Delete entire panel
601-206A11 - Recirculation Panel	x	x			
601-206A14 - Propellant Depletion Panel	x	x			Delete S1, S2, S3, S4, S5, S6, S7, S9, S10, S11 Delete DS1, DS2, DS3, DS4, DS5, DS6, DS7, DS9, DS10, DS11, DS12, DS13, DS14, DS15, DS17, DS18, DS19, DS20, DS21, DS25, DS26 DS27, DS28, DS29
601-209A2 - EBW & Ordnance Panel	x		x		Reidentify M1, M2, DS1, DS7 Add 5 indicators (Fig. 7-14, -15)
601-215A1 - S-II Events Display Panel	x	x	x		Delete 9 indicators
S-II APS Pneumatic Panel			x		
S-II APS Launch and Monitor Panel		x			New Panel similar to S-IVB APS Pneumatic Panel, 601-419A2 (Fig. 7-16)
601-220A1 - LCC S-II Patch Distributor	x	x	x		New Panel similar to S-IVB APS Launch & Monitor Panel, 601-419A1 (Fig. 7-17) Add 18 patches Add 13 Relays Delete 163 Patches Deactivate K11, K34, K35, K50, K118, K125, K1022, K1023, K1024, K1025, K1026, K1052, K1054

TABLE 7.2 - ELECTRICAL CHANGES

GSE Item	USED ON:				Modification
	S-II, No Restart	S-III, One Restart	S-IVB, One Restart	S-IVB, Two Restarts	
601-221A1 - LCC S-II Patch Distributor	x	x			Add 106 Patches Add 7 Relays Delete 202-221A2 Unit Delete 152 Patches Deactivate K204, K208, K210, K211, K212, K213, K214
601-1456A32	x	x	x		Delete 1 Circuit
5975 - S-II Measurements Rack	x	x	x		Delete 3 measurements
<u>S-II ML ESE</u>					
202-221A1 - ML S-II Patch Distributor	x	x	x		Delete 3 Patches Deactivate K206, K207 Add 24 Patches
202-224A1 - ML S-II Patch Distributor	x	x	x		Add 56 Patches Add 24 Relays
+2D500 Power Supply - 56 VDC 201-268A2	x	x	x		Delete 202-224A2 Unit Delete 49 Patches Deactivate K801, K802, K803, K804, K805, K806, K807, K808, K809, K810, K818, K819, K829, K830, K831, K832, K833, K834, K842, K847, K848, K861, K867, K868 Delete Power Supply

TABLE 7.2 - ELECTRICAL CHANGES

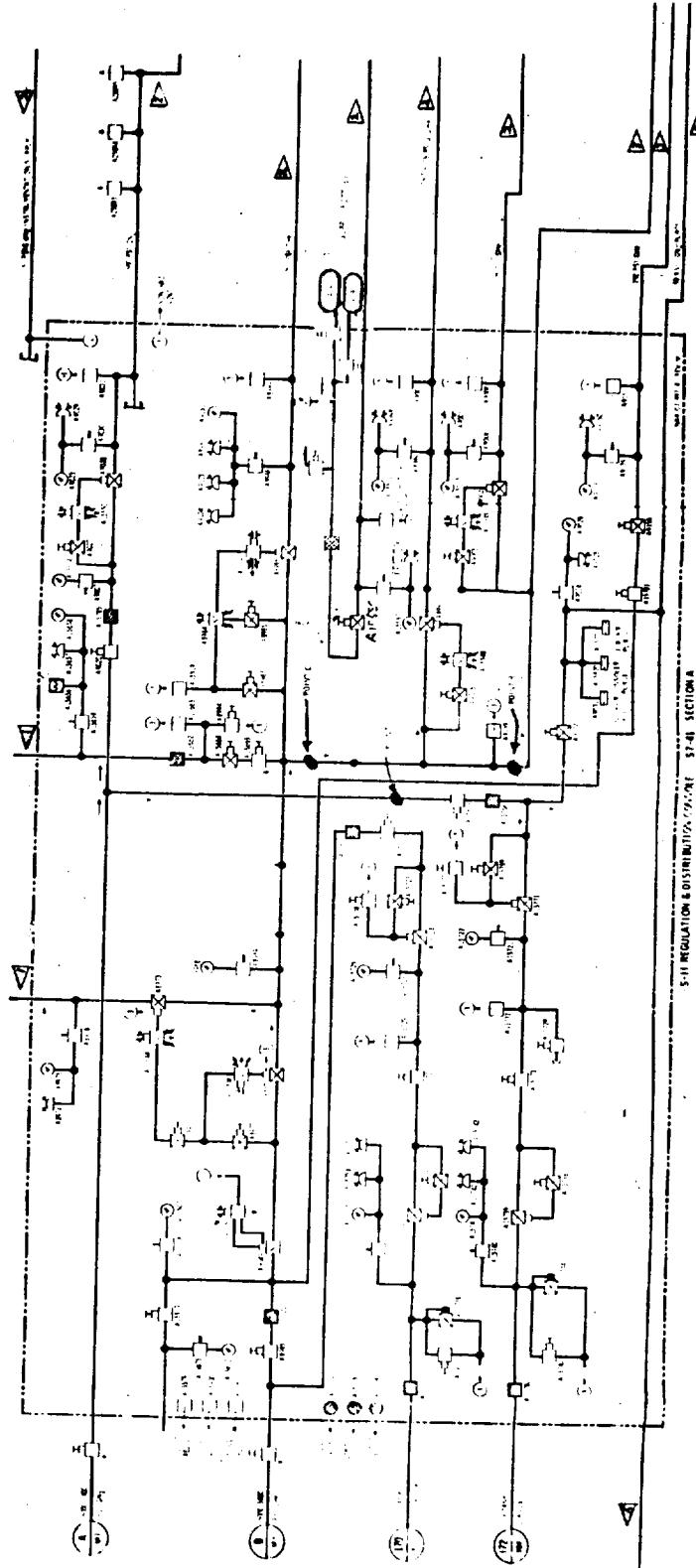
GSE Item	USED ON:			Modification
	S-II, No Restart	S-II, One Restart	S-IVB, One Restart	
202-6600 - S-II Propellant Loading Patch Distributor	x	x		Delete 2 Patches
202-222A1 - ML S-II Patch Distributor	x	x		Delete 24 Patches Deactivate K202, K414, K415, K432, K433, K439, K440
6161 - ML S-II Crossover Distributor		x		Add 26 Patches Add 4 Relays
202-220A1 - ML S-II Patch Distributor	x	x	x	Delete 102 Patches Delete 118 Patches
201-265A2 - S-II Power System Distributor	x	x	x	Delete 5 Patches Deactivate K78, K93 Add 32 Patches
9017 - Umbilical Power Distributor	x	x	x	Delete 1 Patch
9073 - Terminal Distributor	x	x	x	Delete 2 Patches
201-262B2 - Bus Terminal Assembly	x	x	x	Delete 2 Patches
201-262A4 - 5DC Module Type VIIIA-1	x	x	x	Delete DS1, DS2

TABLE 7.2 - ELECTRICAL CHANGES

GSE Item	USED ON:		Modification	
	S-II, No Restart	S-II, One Restart	S-IVB, One Restart	S-IVB, Two Restarts
6201 - ML S-II Crossover Distributor	x	x		Delete 28 Patches
202-223A1 - ML S-II Patch Distributor	x	x		Delete 18 Patches Add 29 Patches
<b>GSE SYSTEMS (S-II CHANGES)</b>				
110A Computer		x		Add 141 Channels Modify Software
DDAS		x		Delete 161 Channels Modify Software
DEE-6		x		Add 44 Channels Modify Software
OIS		x		Add 5 Channels Delete 13 Channels
PTCS	x	x		Add 58 Channels Delete 57 Channels
CIF Telemetry and Data Display	x	x		Add 4 OIS Boxes and 2 Phones on MSS Platform #1 for S-II APS Servicing Operations Modify Software Instrumentation Channel Reallocation

TABLE 7.2 - ELECTRICAL CHANGES

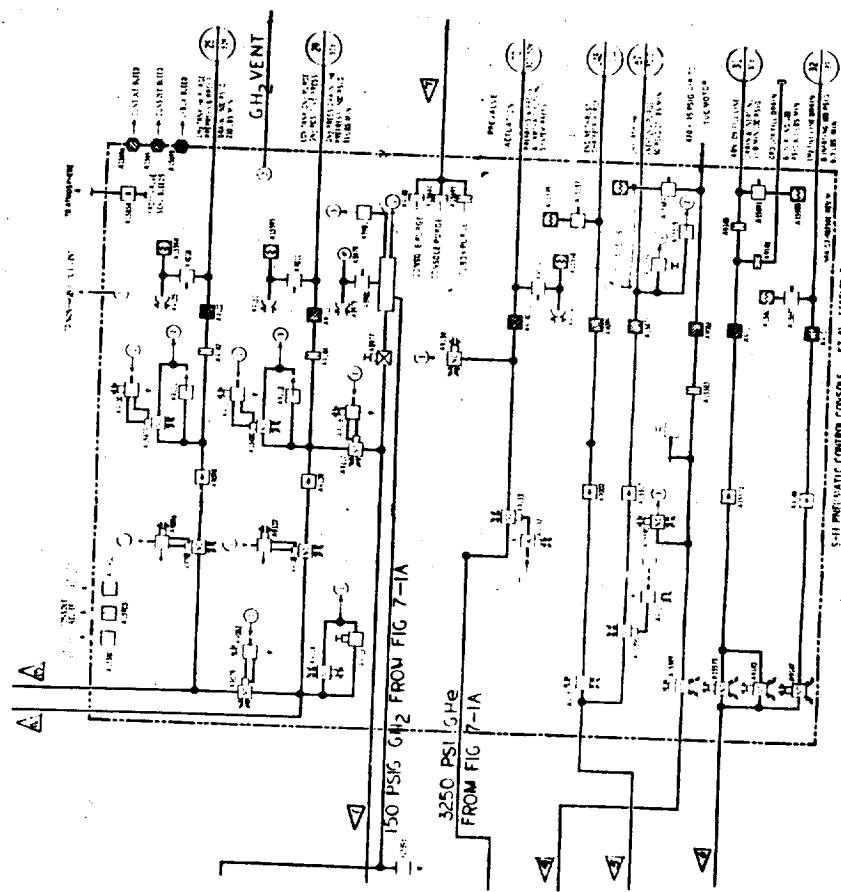
GSE Item	USED ON:				Modification
	S-II, No Restart	S-II, One Restart	S-IVB, One Restart	S-IVB, Two Restarts	
Cross Country Cabling	x	x			No new cabling identified
Facility Power					
OTV		x			
<u>S-II TCC</u>			x		
Engine Test Panels (5)	x				
Stage Pressure Panel	x		x		
808-262A4 - S-II LowBay Power System Patch Dist.	x		x		
808-220A1 - S-II LowBay Patch Distributor	x		x		
808-222A1 - S-II LowBay Patch Distributor	x		x		



▲ To Fig. 7-1D  
 △ To Fig. 7-1B  
 ▽ To Fig. 7-1C  
 □ To Fig. 7-1B & 7-1C  
 50 psig site Purge to Fig. 7-1D

S-II REGULATION & DISTRIBUTION CONSOLE  
S7-41 SECTION A

FIGURE 7-1A



S-II PNEUMATIC CONTROL CONSOLE  
ST41

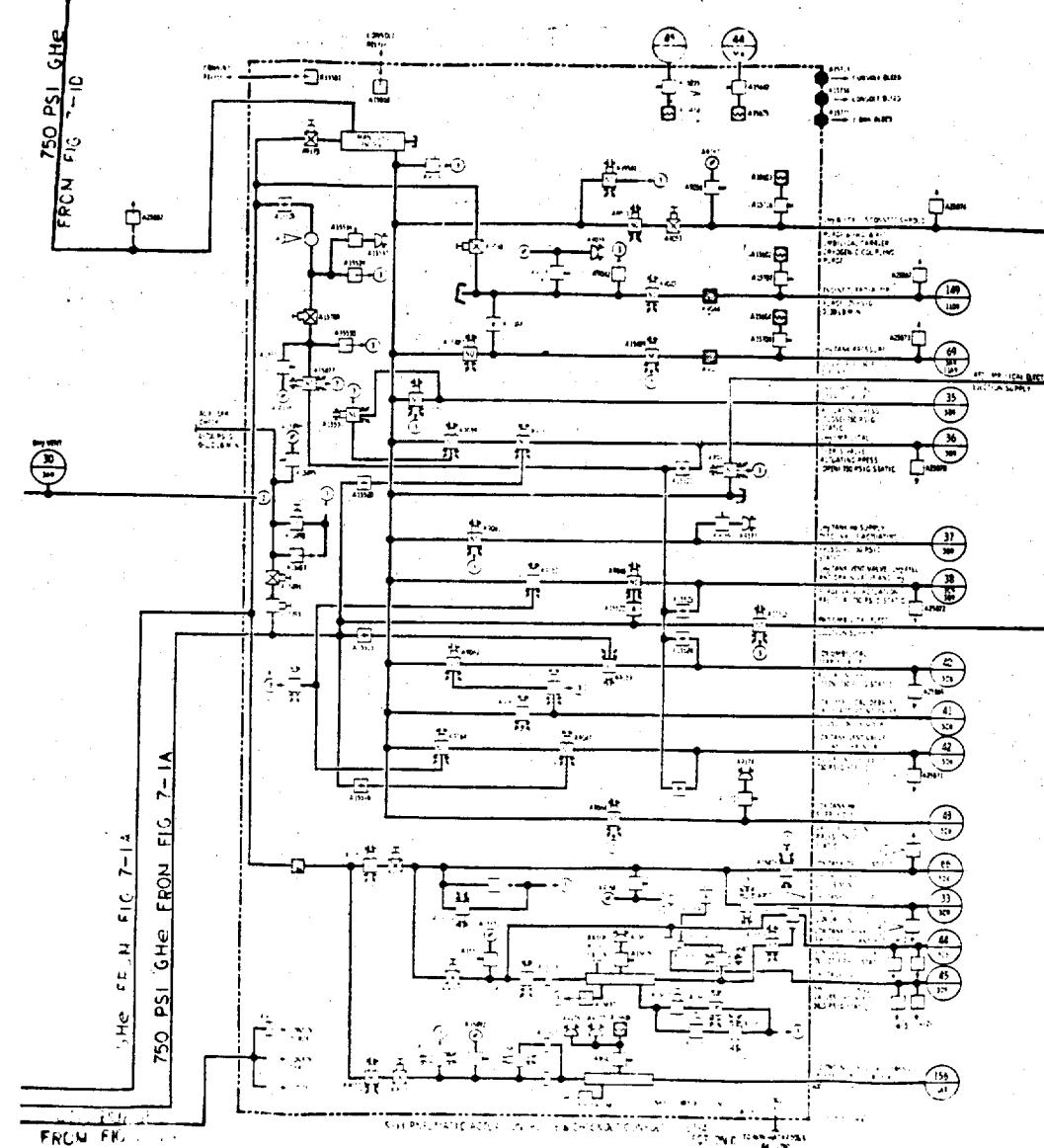
FIGURE 7-1B

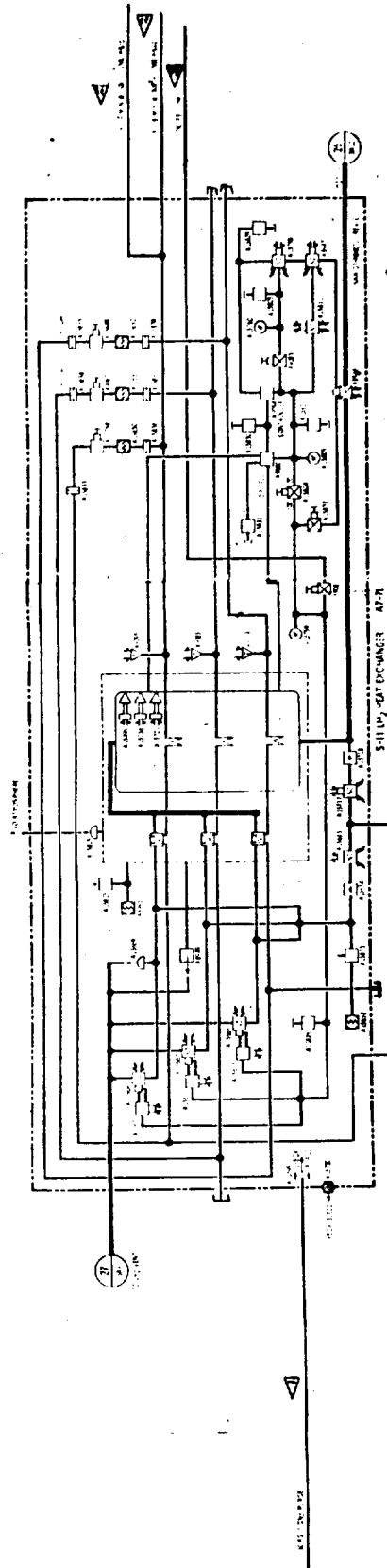
SHEET 61

S-11 PNEUMATIC ACTUATION,  
PURGE & CHECKOUT  
CONSOLE S7-41C  
FIGURE 7-1C

NUMBER 05-16793  
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THE BOEING COMPANY





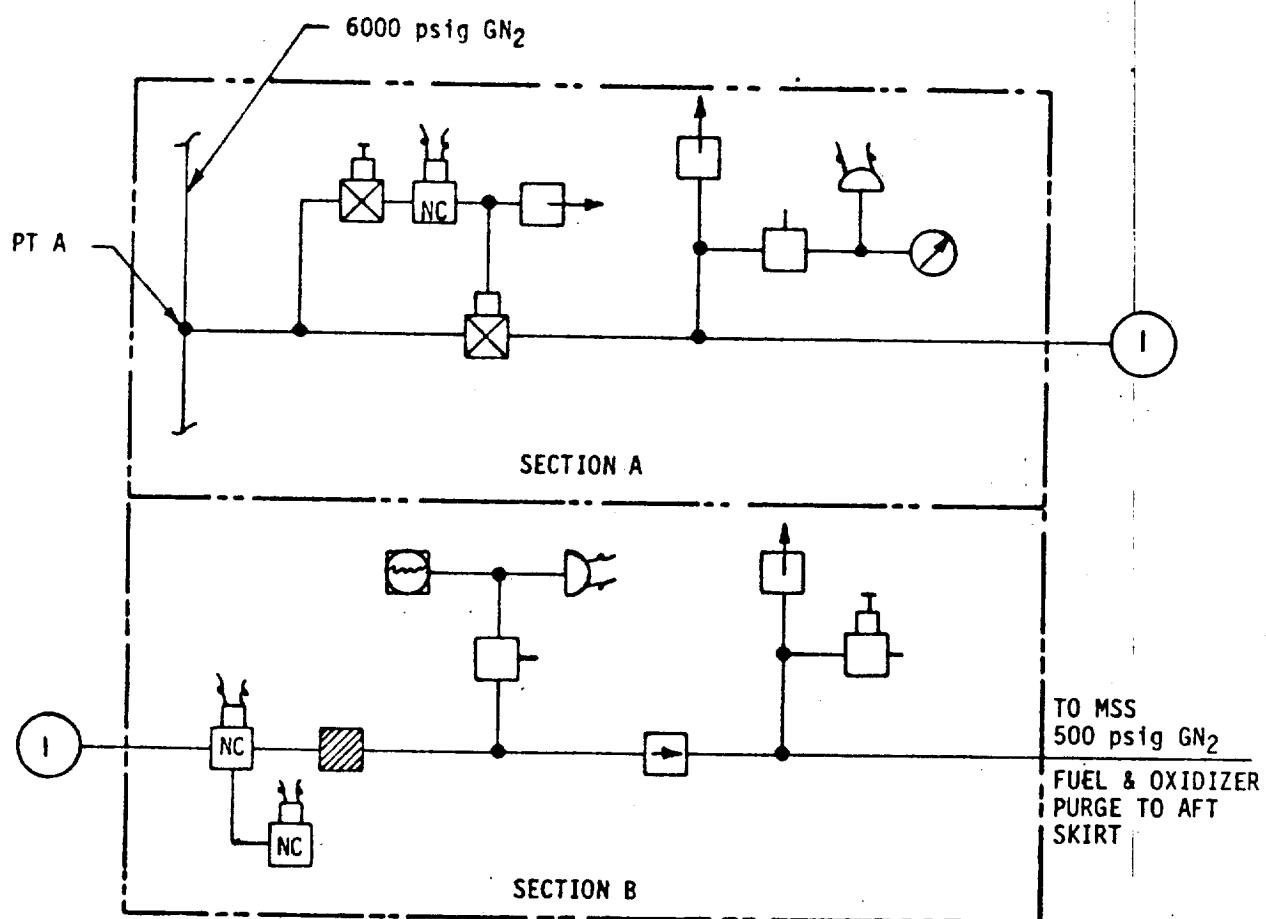
S-II LH<sub>2</sub> HEAT EXCHANGER  
A7-71

A7-71

**FIGURE 7-10**

- From Fig. 7-1A
  - To Fig. 7-1B
  - To Fig. 7-1C

USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL

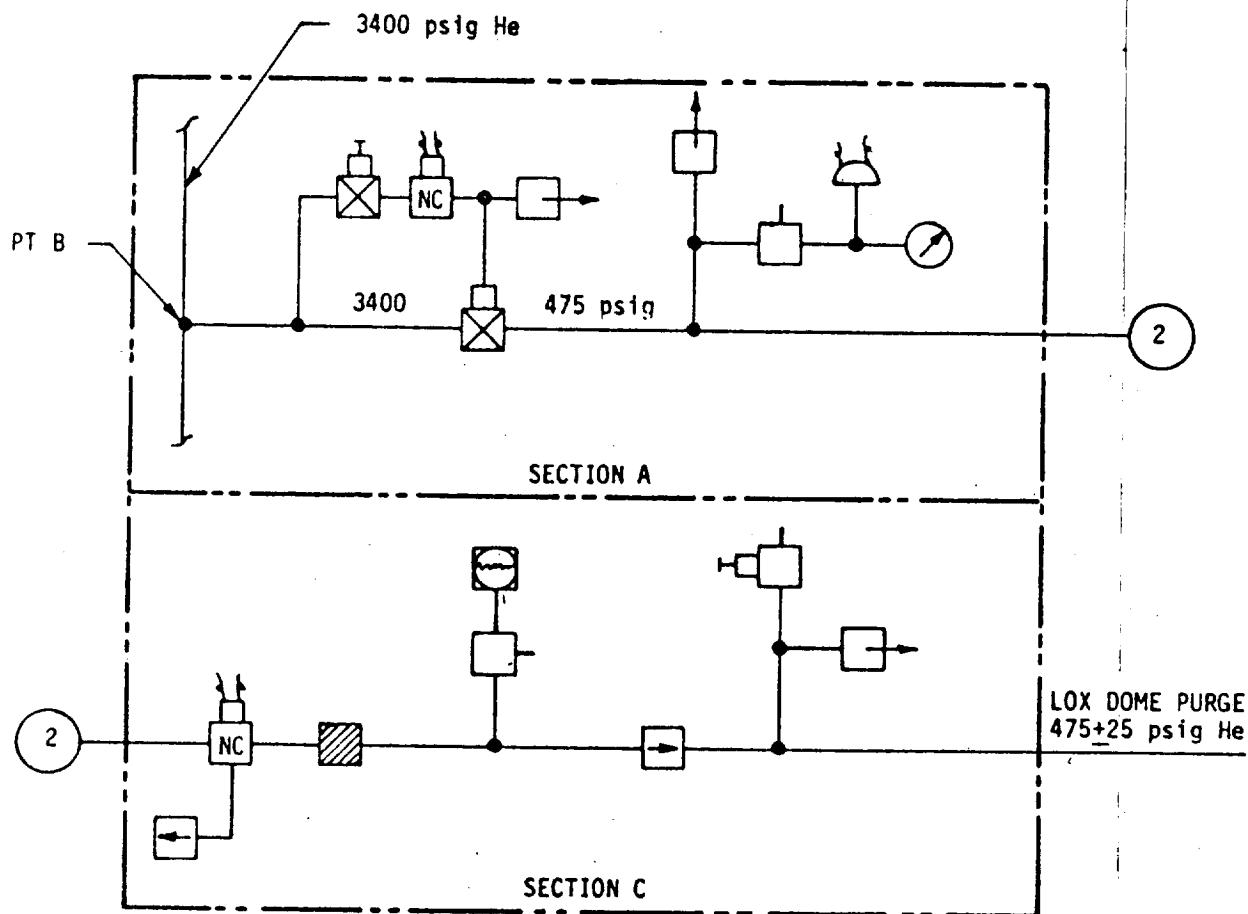


## S-II REGULATION AND DISTRIBUTOR CONSOLE

POINT A  
(See Fig. 7-1A)

FIGURE 7-2

USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL

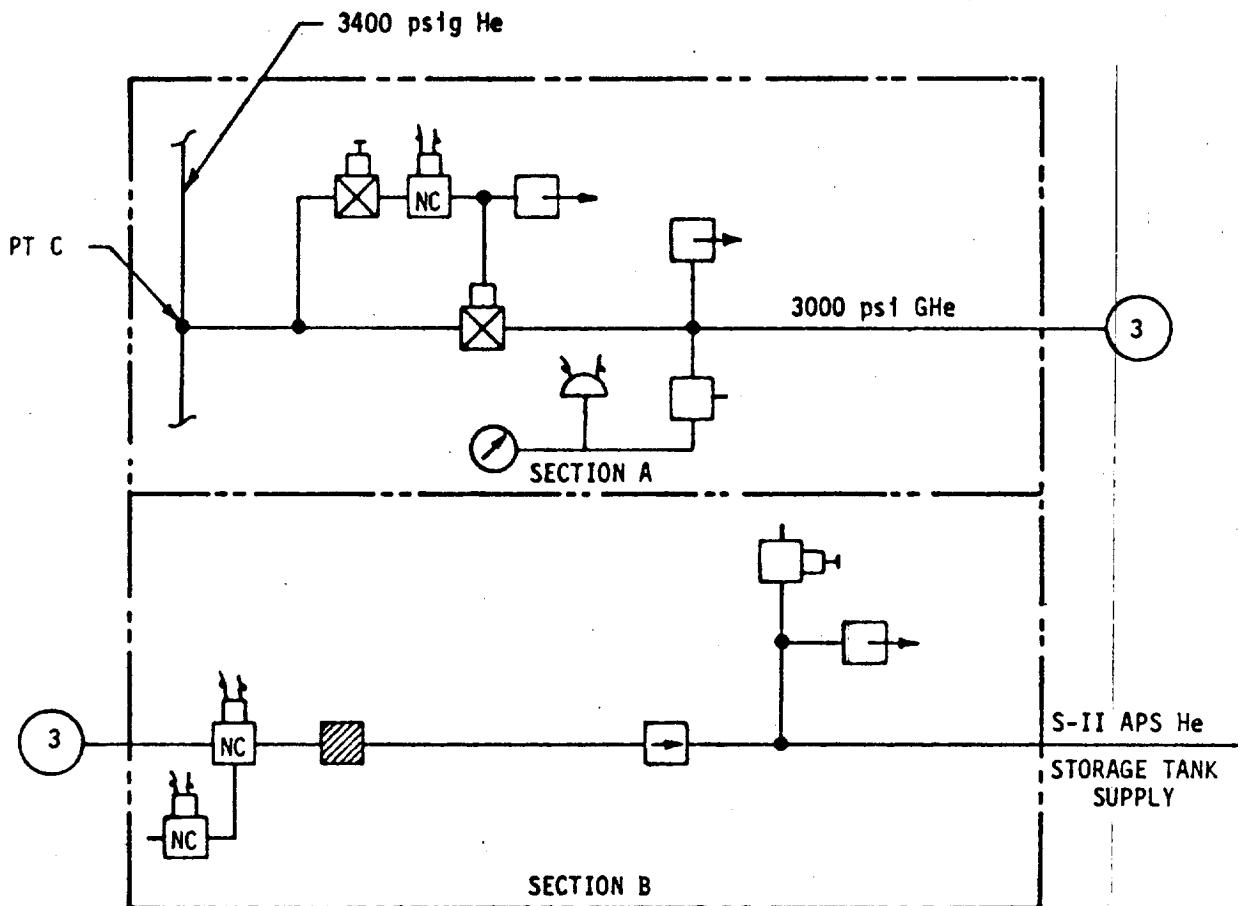


## S-II REGULATION AND DISTRIBUTION CONSOLE

POINT B  
(See Fig. 7-1A)

FIGURE 7-3

USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL



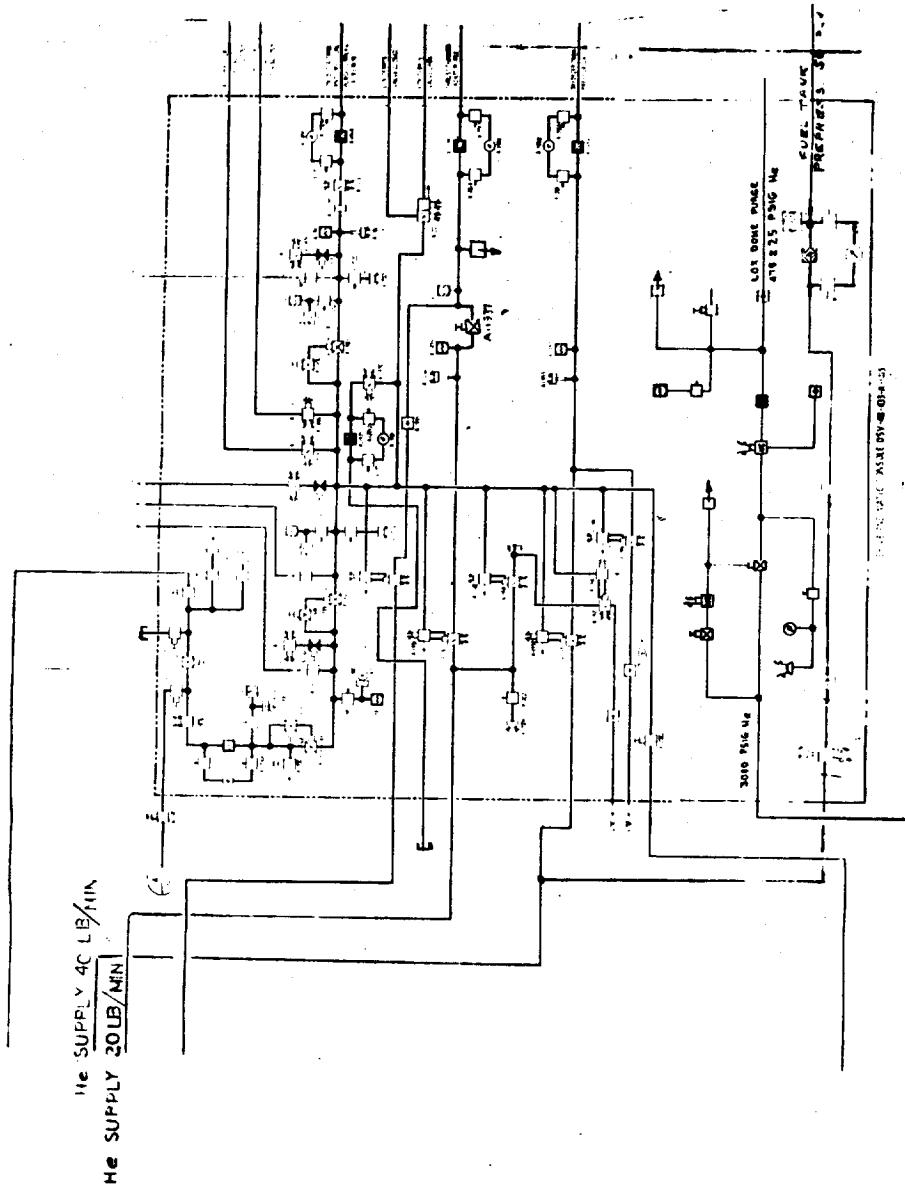
## S-II REGULATION AND DISTRIBUTION CONSOLE

POINT C  
(See Fig. 7-1A)

FIGURE 7-4

NUMBER D5-16793  
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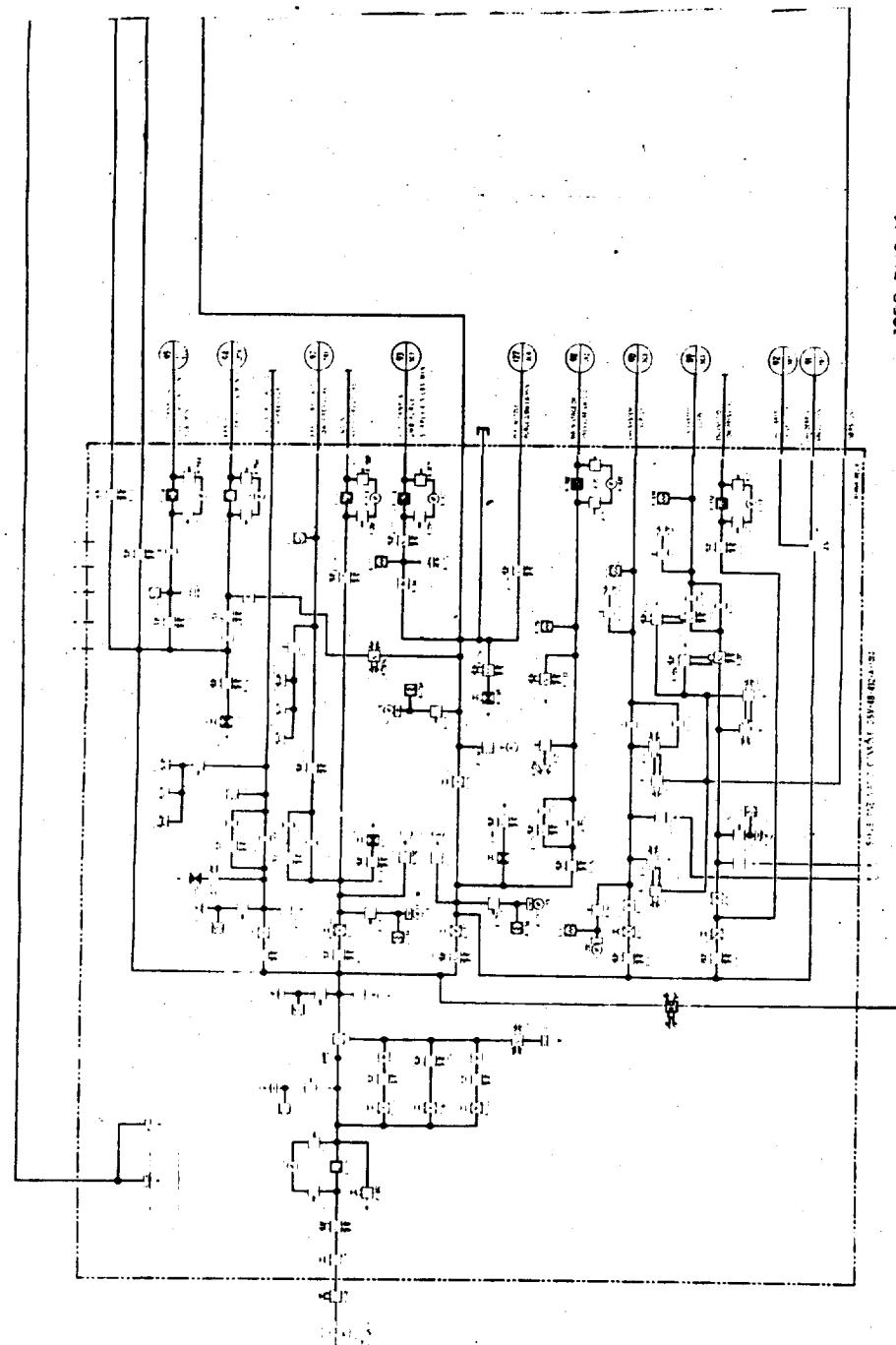


S-IVB PNEUMATIC CONSOLE  
DSV-4B-432A-1415  
FIGURE 7-5A

SHEET 66

NUMBER 05-16793  
REV LTR

**THE BOEING COMPANY**



305 C. P. 16 M.

S-INV PNEUMATIC CONSOLE  
DSV-4B-432A-1414

FIGURE 7-5B

SHEET 67

USE FOR TYPEWRITTEN MATERIAL ONLY

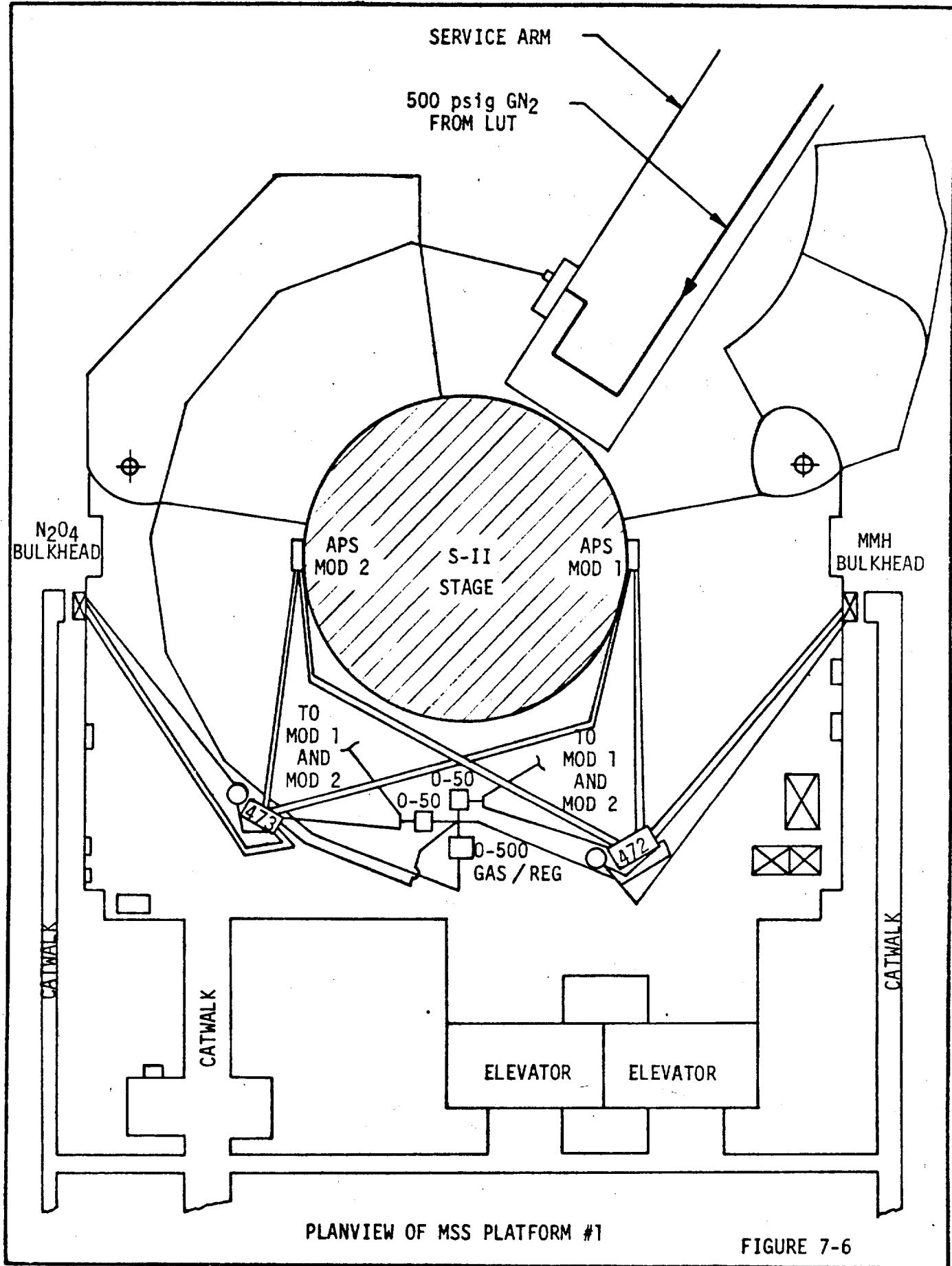
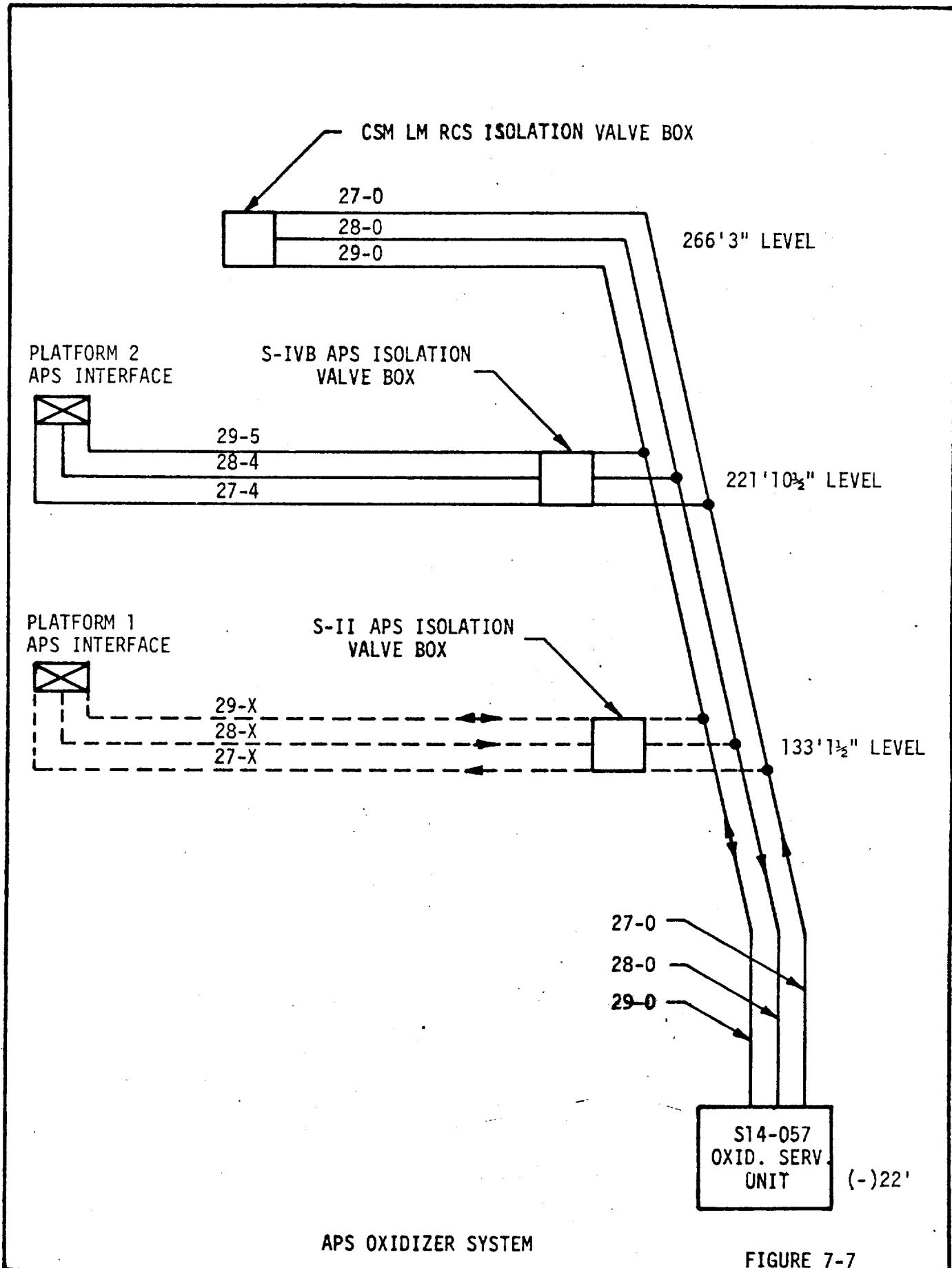
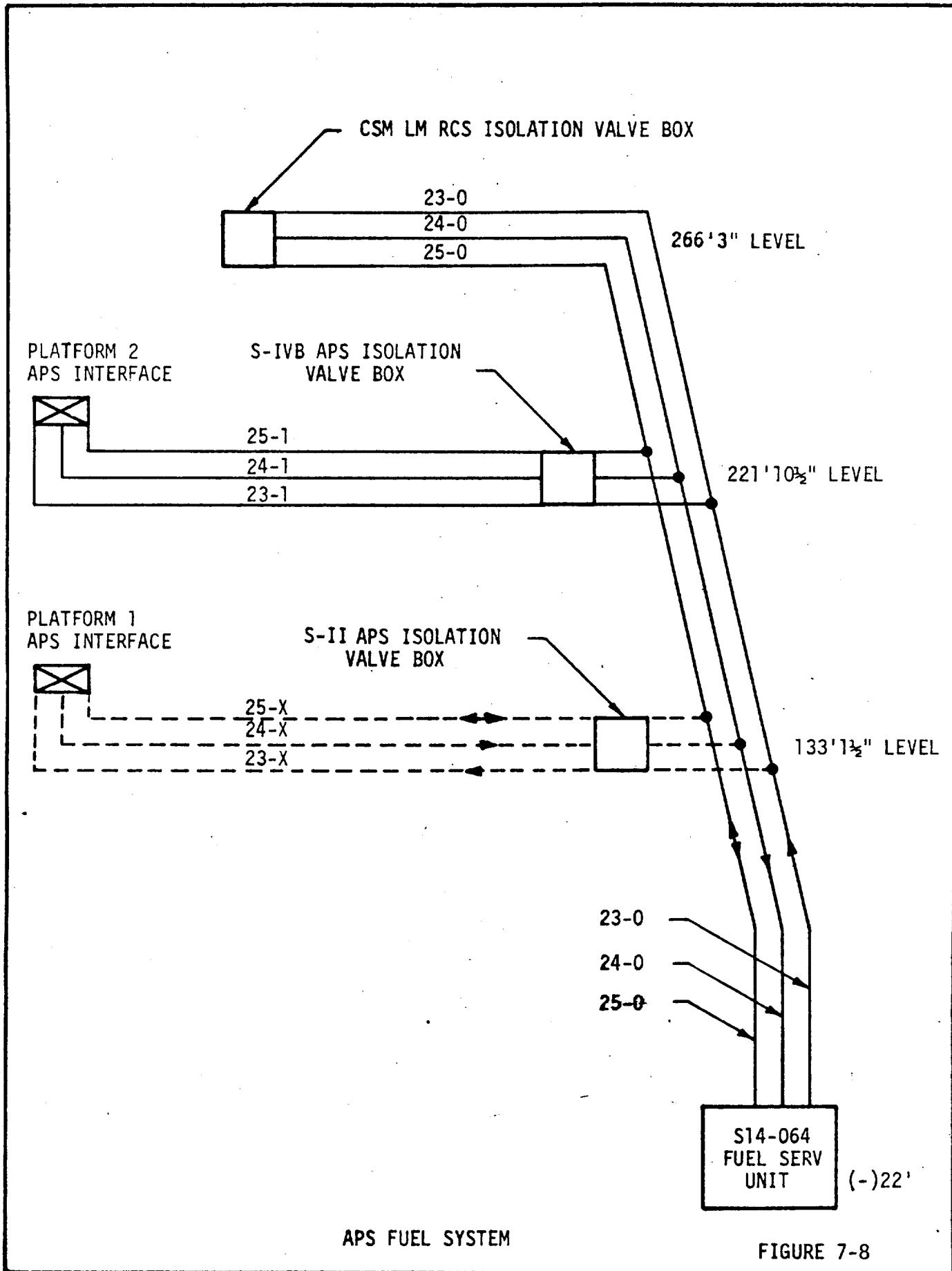


FIGURE 7-6

USE FOR TYPED MATERIAL ONLY



USE FOR TYPEWRITTEN MATERIAL ONLY



USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL

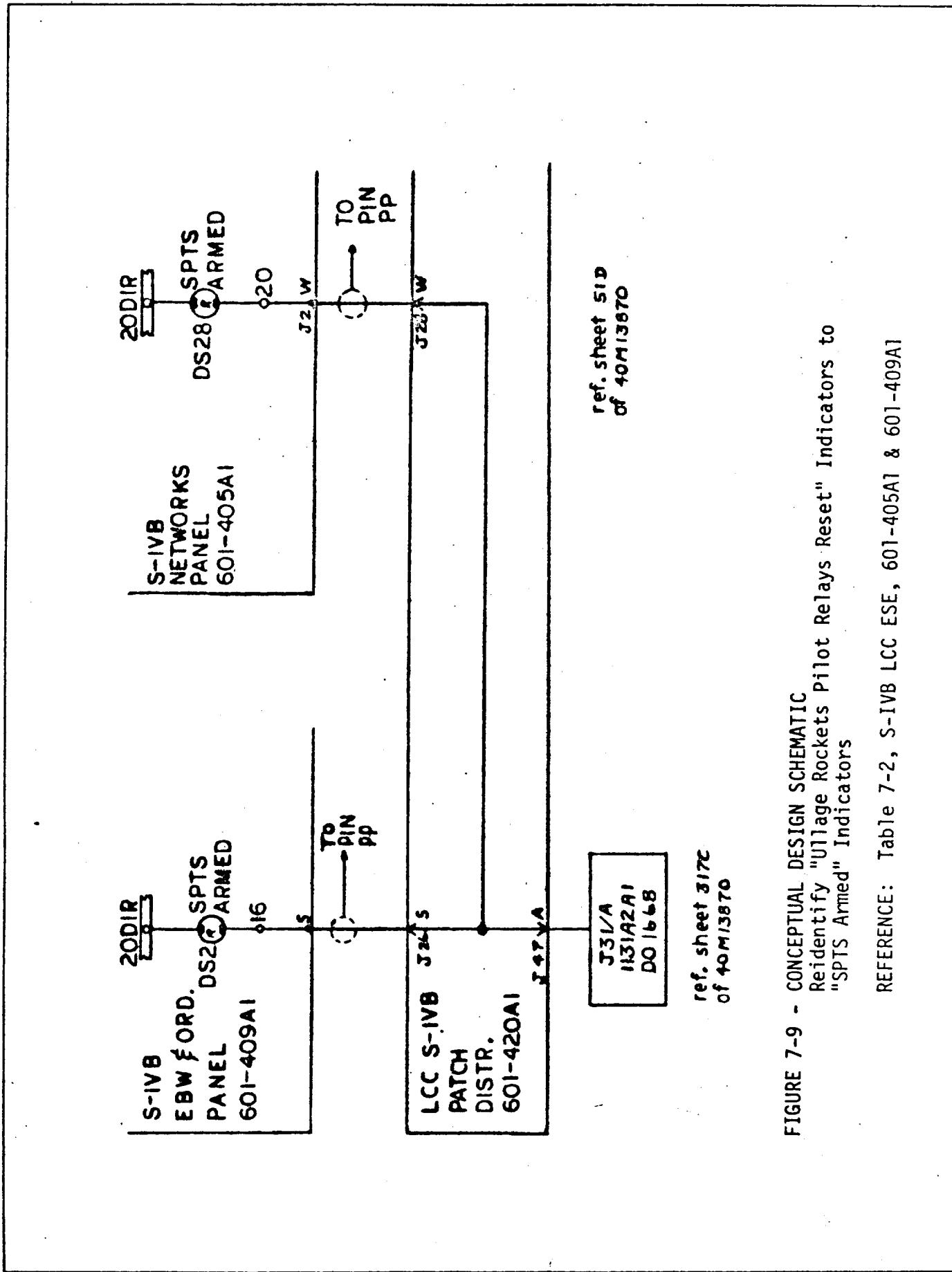


FIGURE 7-9 - CONCEPTUAL DESIGN SCHEMATIC  
Re identify "Ullage Rockets Pilot Relays Reset" Indicators to  
"SPTS Armed" Indicators

REFERENCE: Table 7-2, S-IVB LCC ESE, 601-405A1 & 601-409A1

USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL

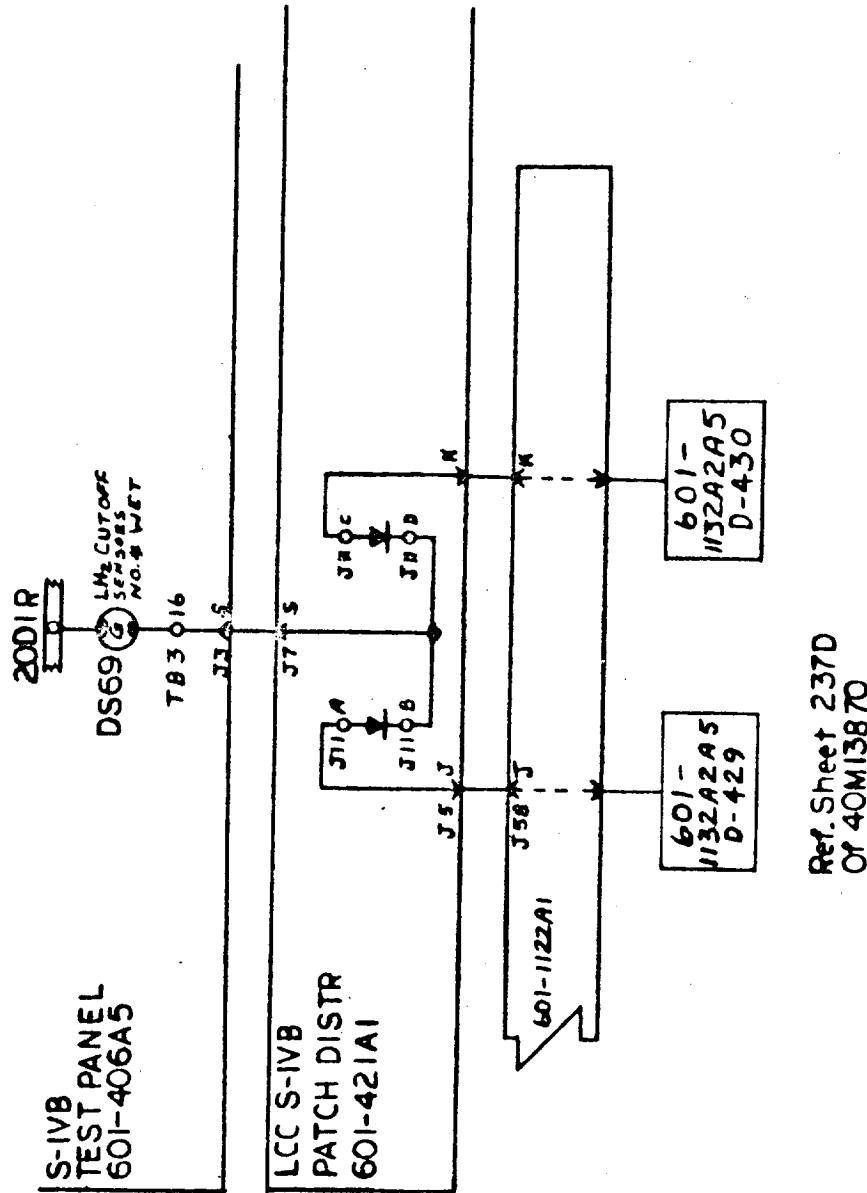


FIGURE 7-10 - CONCEPTUAL DESIGN SCHEMATIC  
Reidentify "LOX/LH Cutoff Sensors No. 4 Wet" Indicator  
to "LH Cutoff Sensors No. 4 Wet" Indicator

REFERENCE: Table 7-2, S-IVB LCC ESE, 601-406A5

USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL

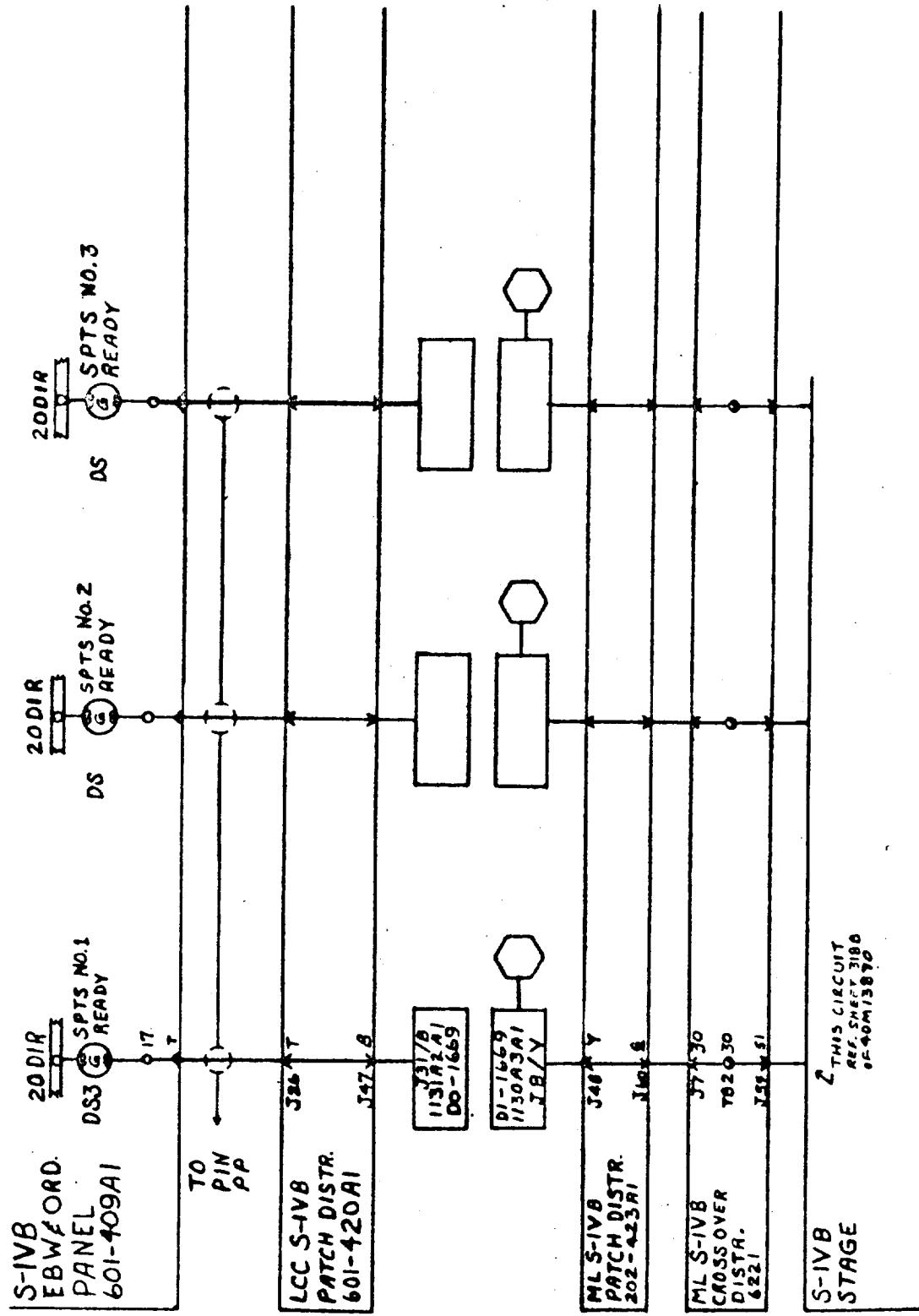
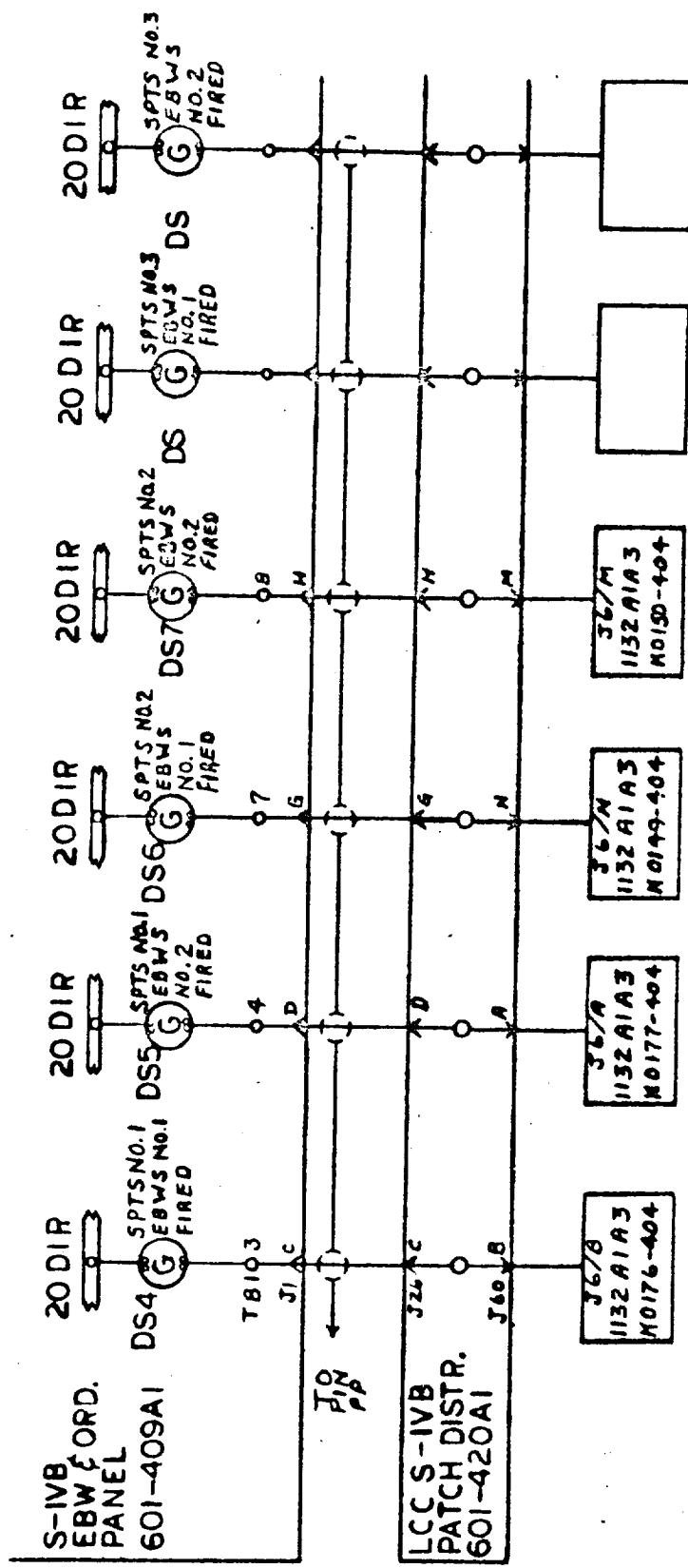


FIGURE 7-11 - CONCEPTUAL DESIGN SCHEMATIC  
Reidentify "Uillage Rockets Firing Unit" Indicators to "SPTS No. 1 Ready"  
and "SPTS No. 3 Ready" indicators

REFERENCE: Table 7-2, S-IVB LCC ESE, 601-409A1

USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL



Ref. Sheet 316B  
Or 40M13870

FIGURE 7-12 - CONCEPTUAL DESIGN SCHEMATIC  
Reidentify "Uillage Rocket Ignition and Jettison Firing Units Pulse Sensor Fired" indicators to "SPTS No. 1 EBW Fired" (2) and "SPTS No. 2 EBW Fired" (2) indicators and add 2 new DS indicators labeled "SPTS EBW No. 1 Fired" and "SPTS EBW No. 2 Fired"

REFERENCE: Table 7-2, S-IVB LCC ESE, 601-409A1

USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL

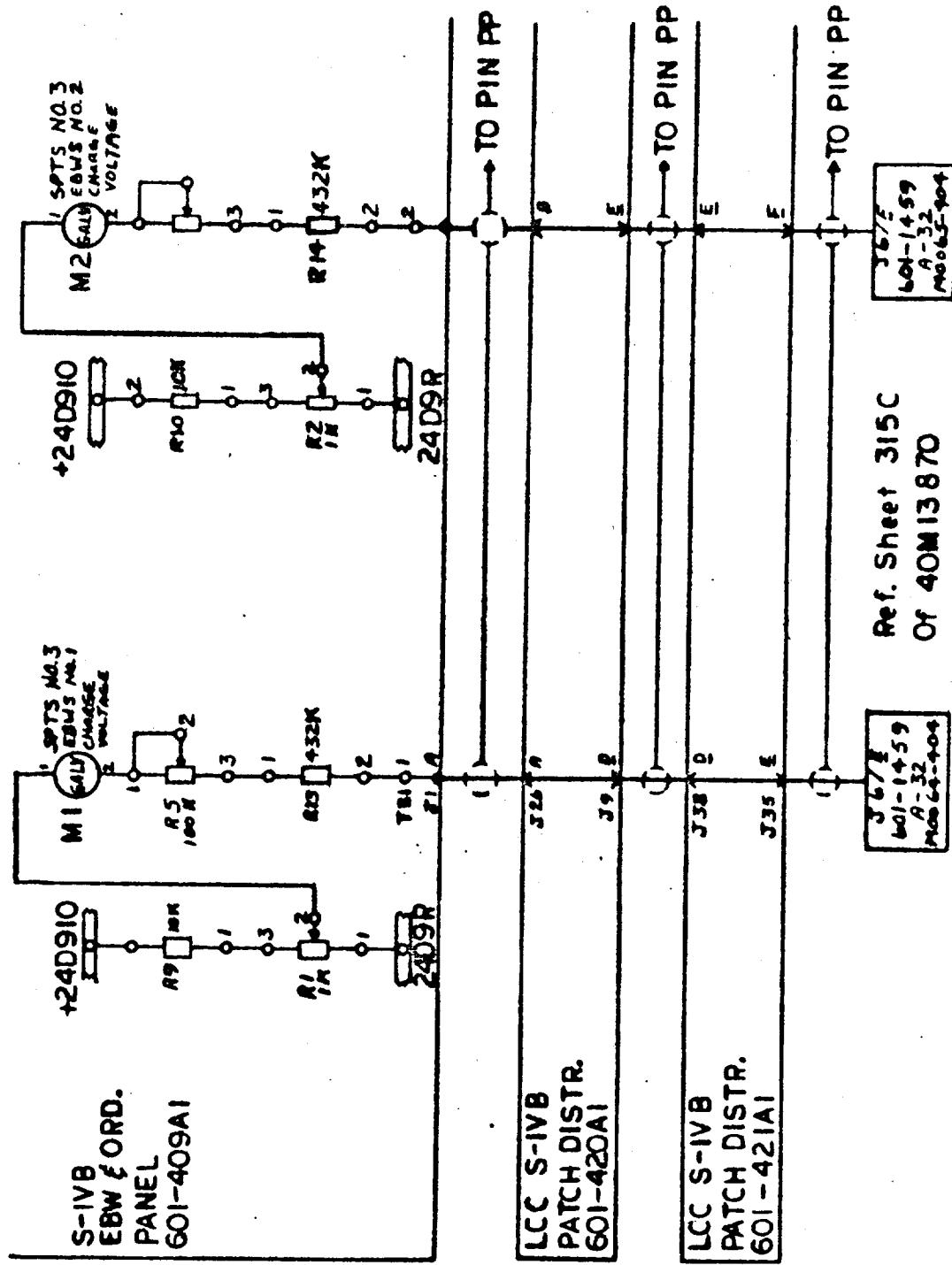


FIGURE 7-13 - CONCEPTUAL DESIGN SCHEMATIC  
Reidentify M1 and M2 from "U11age Rocket Ignition Charge Voltage" to "SPTS  
No. 3 EBW Charge Voltage"  
REFERENCE: Table 7-2, S-IVB LCC ESE, 601-409A1

USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL

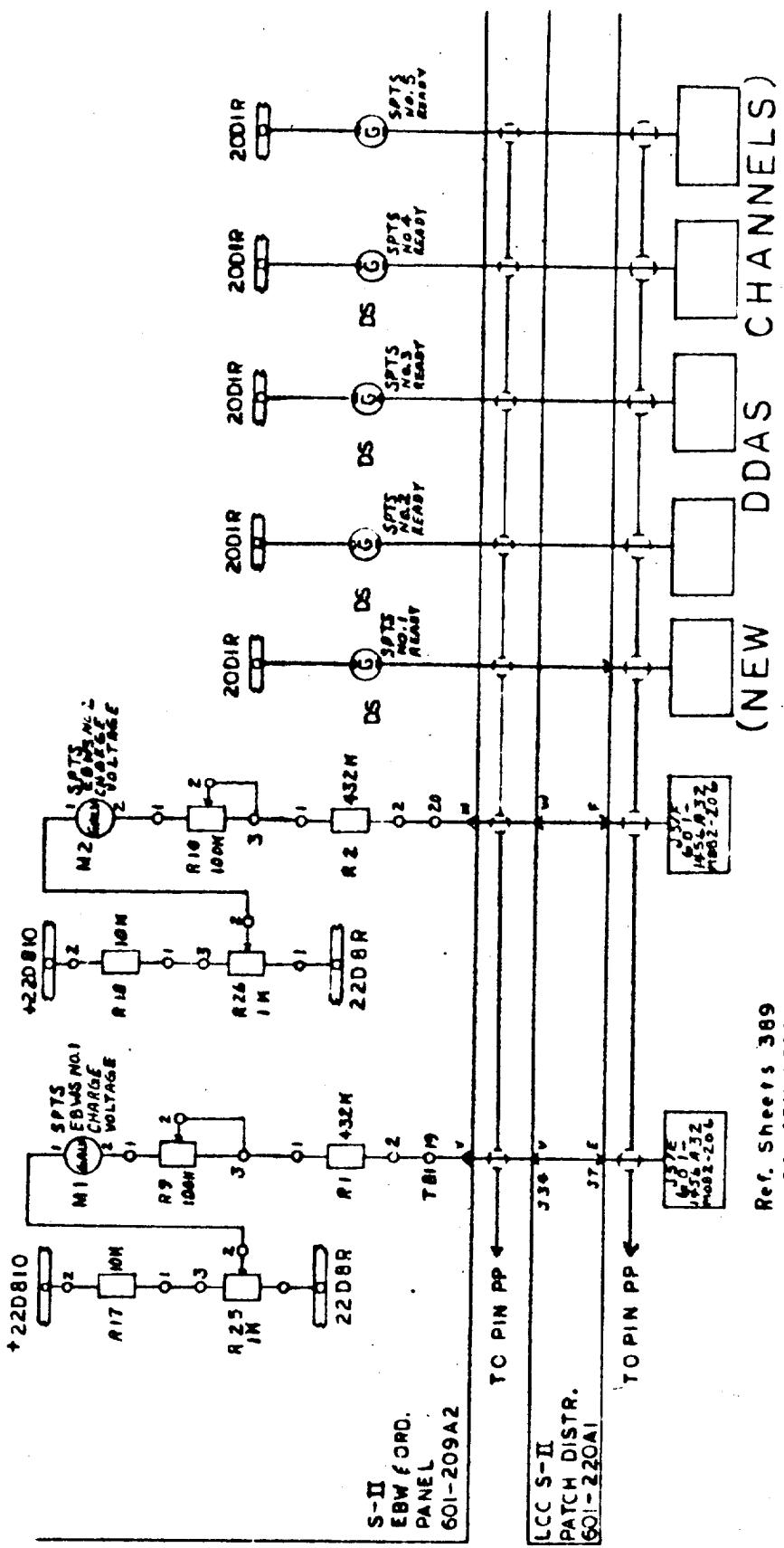


FIGURE 7-14 - CONCEPTUAL DESIGN SCHEMATIC  
Reidentify M1 and M2 from "Ullage Charge Voltage EBW - Nos. 1 and 2" to "SPTS EBS No. 1 and 2 Charge Voltage" and Add 5 new indicators for SPTS 1 through 5 Ready

REFERENCE: Table 7-2, S-II LCC ESE, 601-209A2

USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL

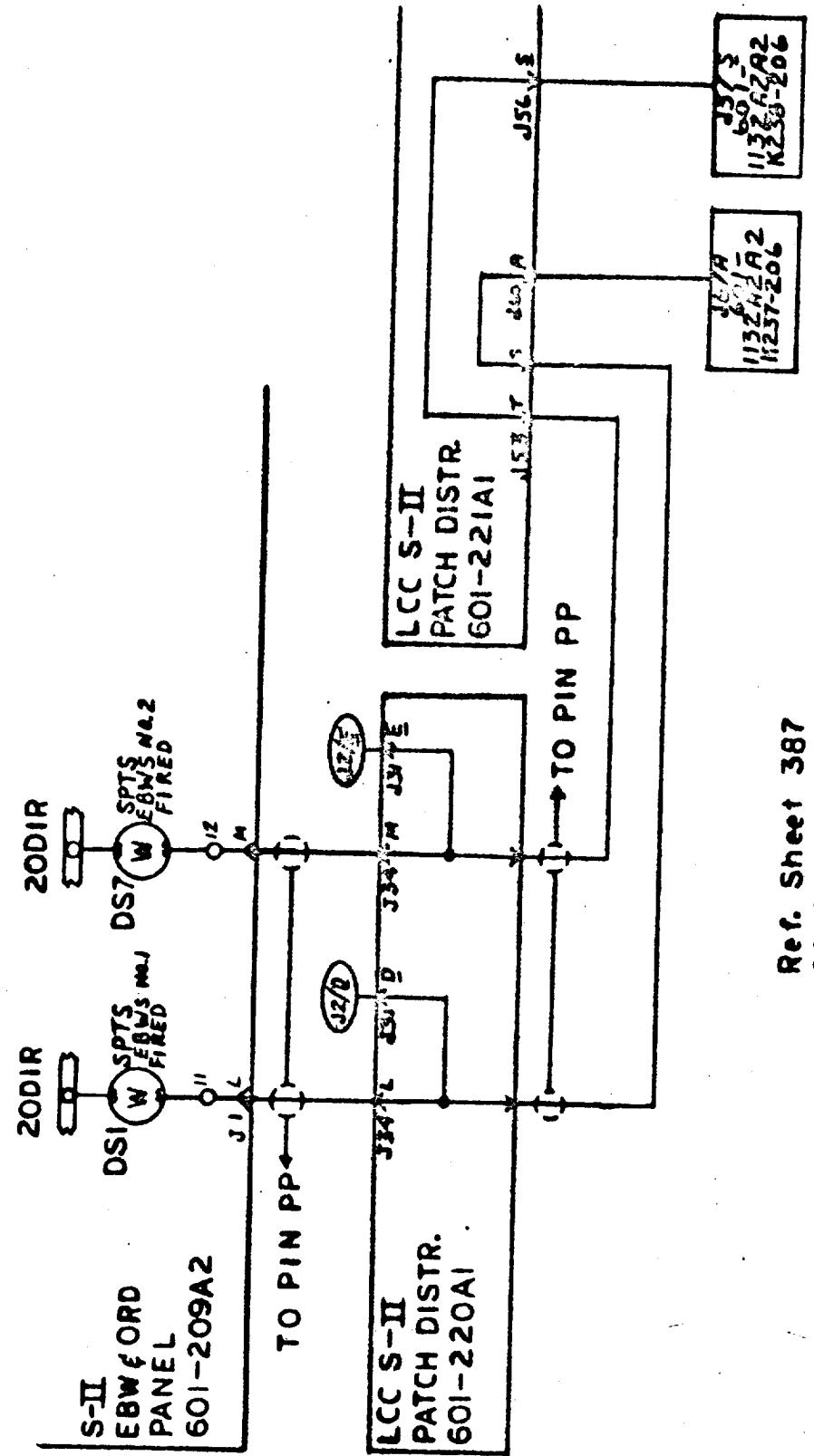
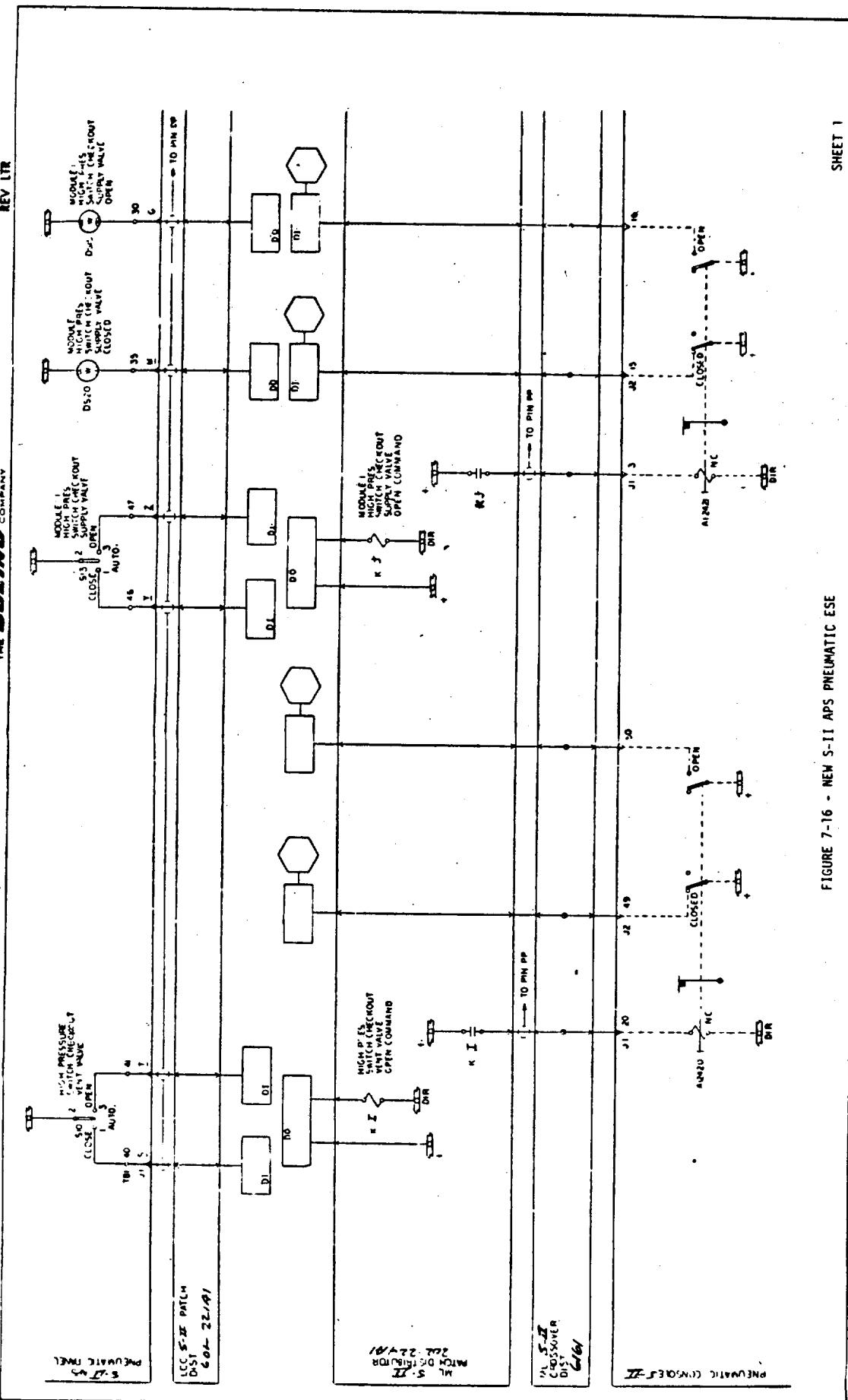


FIGURE 7-15 - CONCEPTUAL DESIGN SCHEMATIC  
For S-II with one restart, reidentify DS1 and DS7 from "SPTS EBW No. 1 and 2 Fired" indicators to "SPTS EBW No. 1 and 2 Fired" indicators.

REFERENCE: Table 7-2, S-II LCC ESE, 601-209A2

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NUMBER D5-17793  
REV LTR

THE BOEING COMPANY

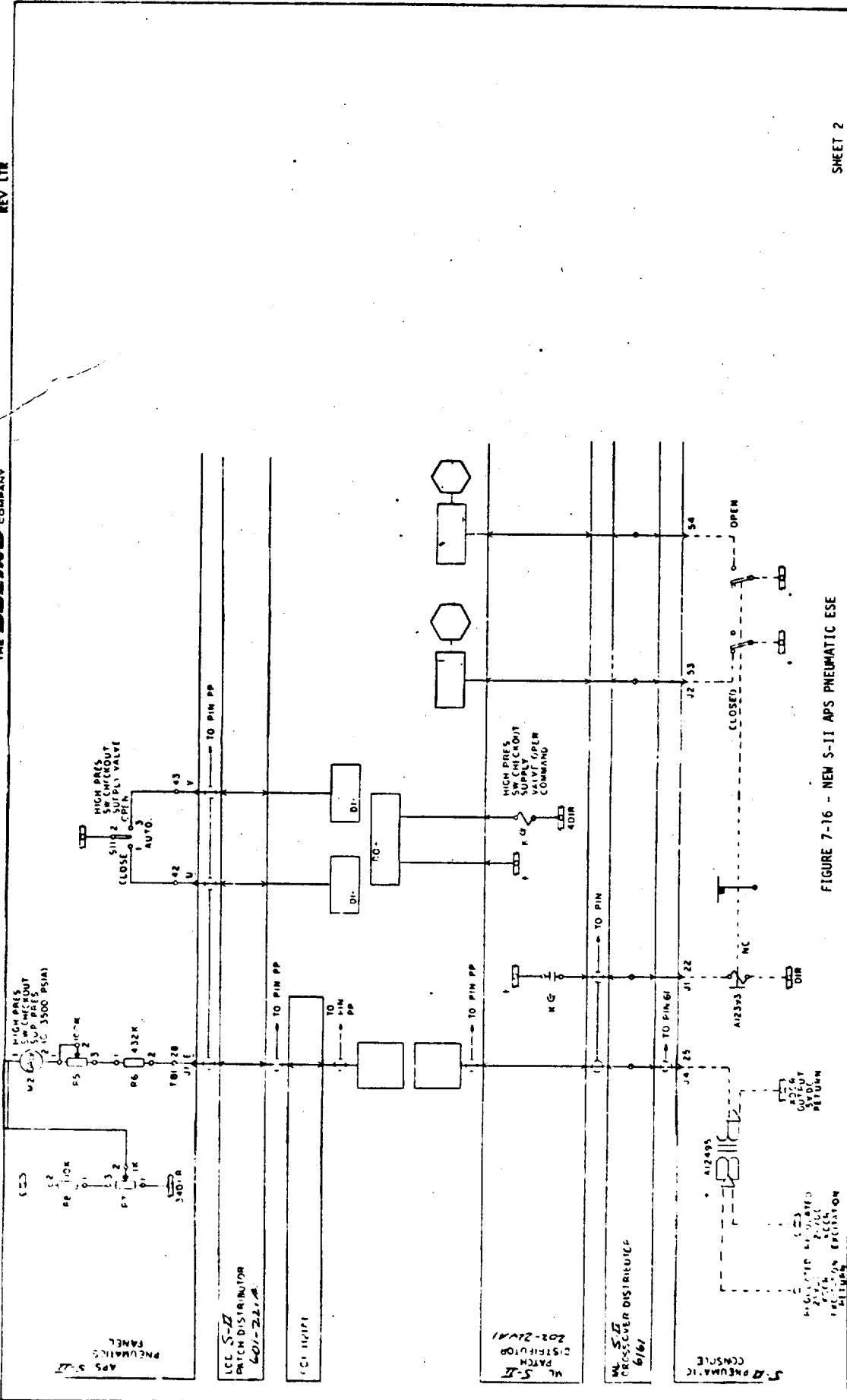


FIGURE 7-16 - NEW S-II APS PNEUMATIC ESE

SHEET 2

SHEET 79

NUMBER D5-14743  
REV LTR

THE BOEING COMPANY

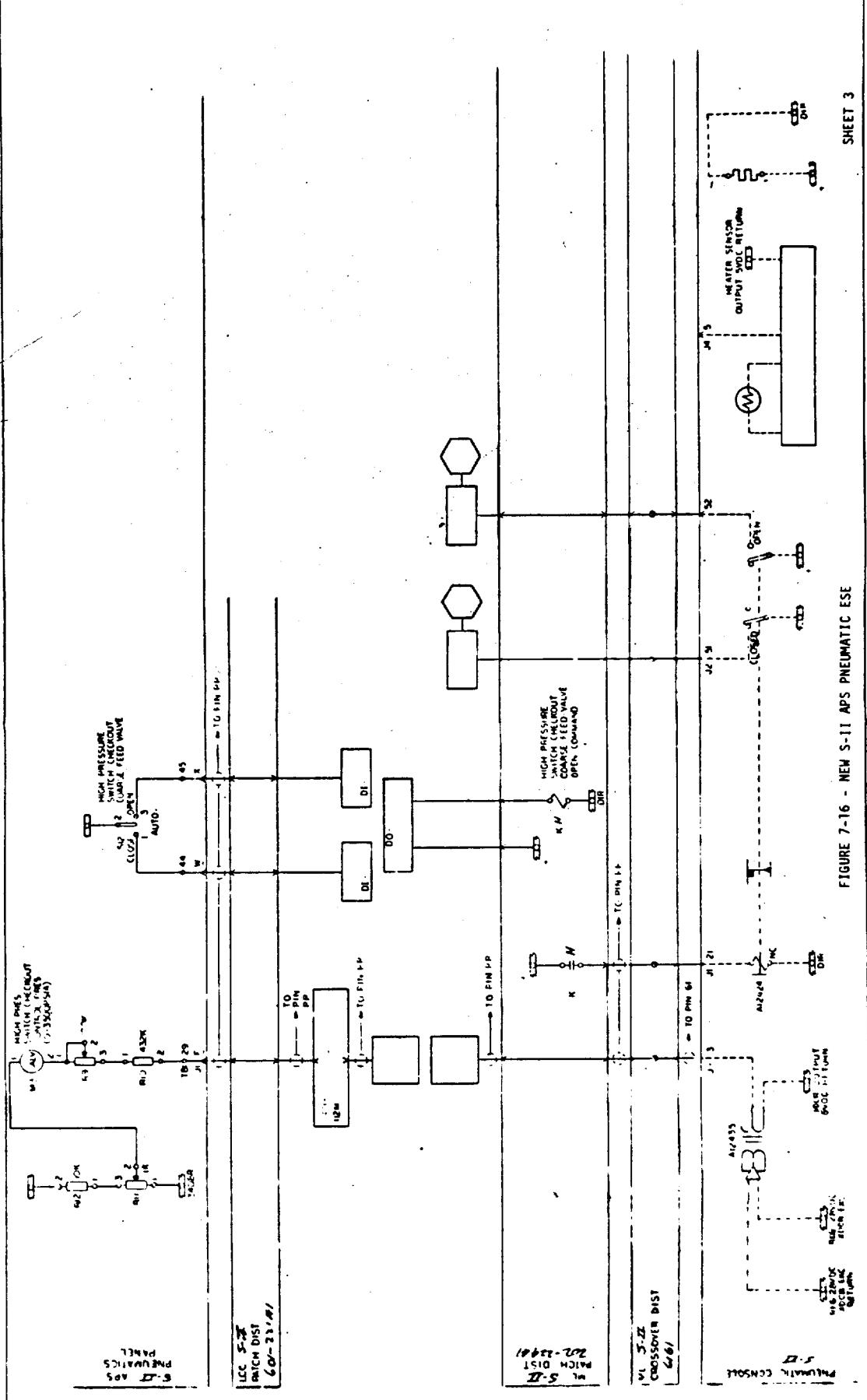
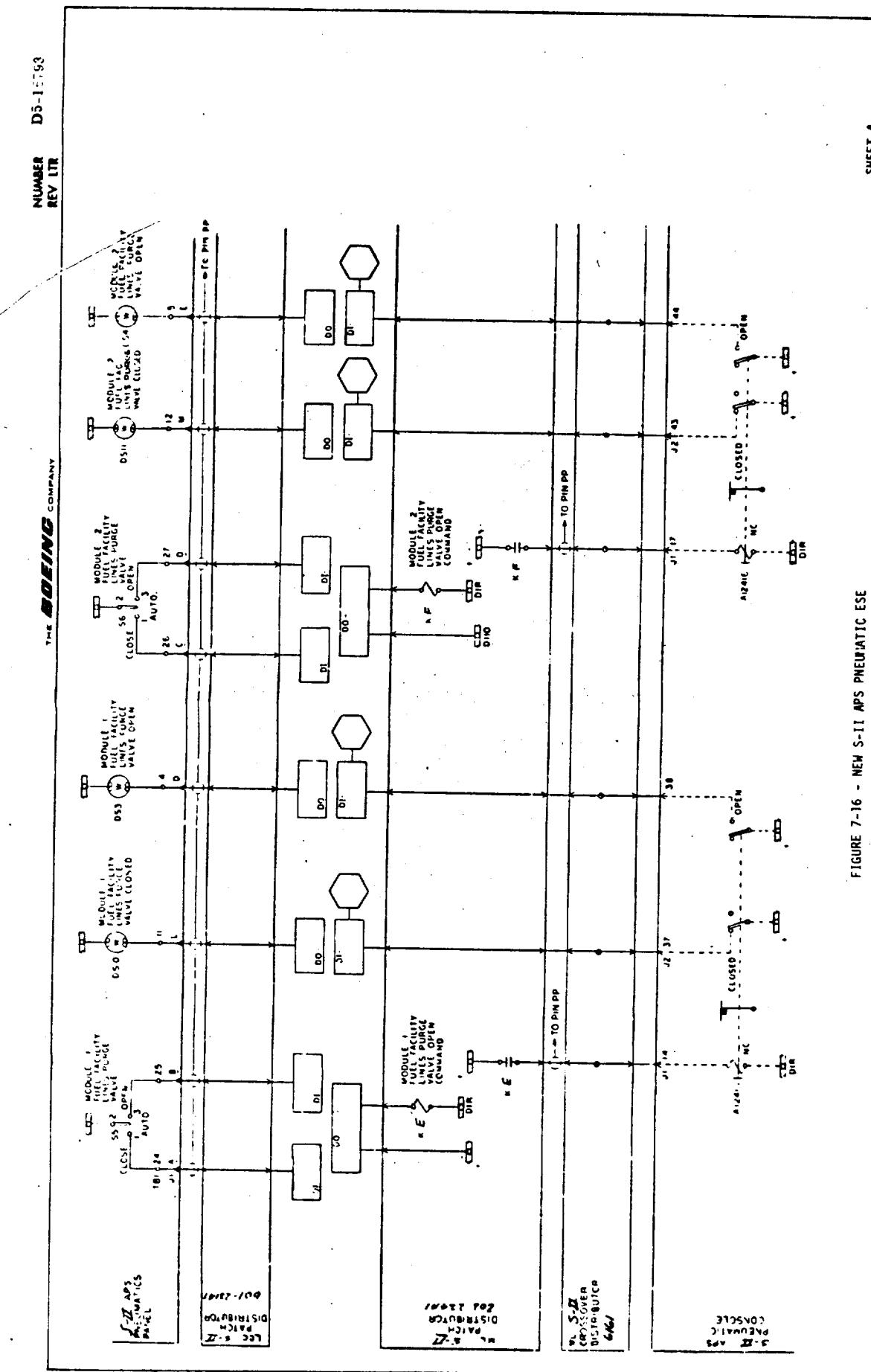


FIGURE 7-16 - NEW S-11 APS PNEUMATIC ESE

SHEET 3

SHEET 80

FIGURE 7-16 - NEW S-II APS PNEUMATIC ESE



NUMBER D5-15793  
REV LTR

THE BOEING COMPANY

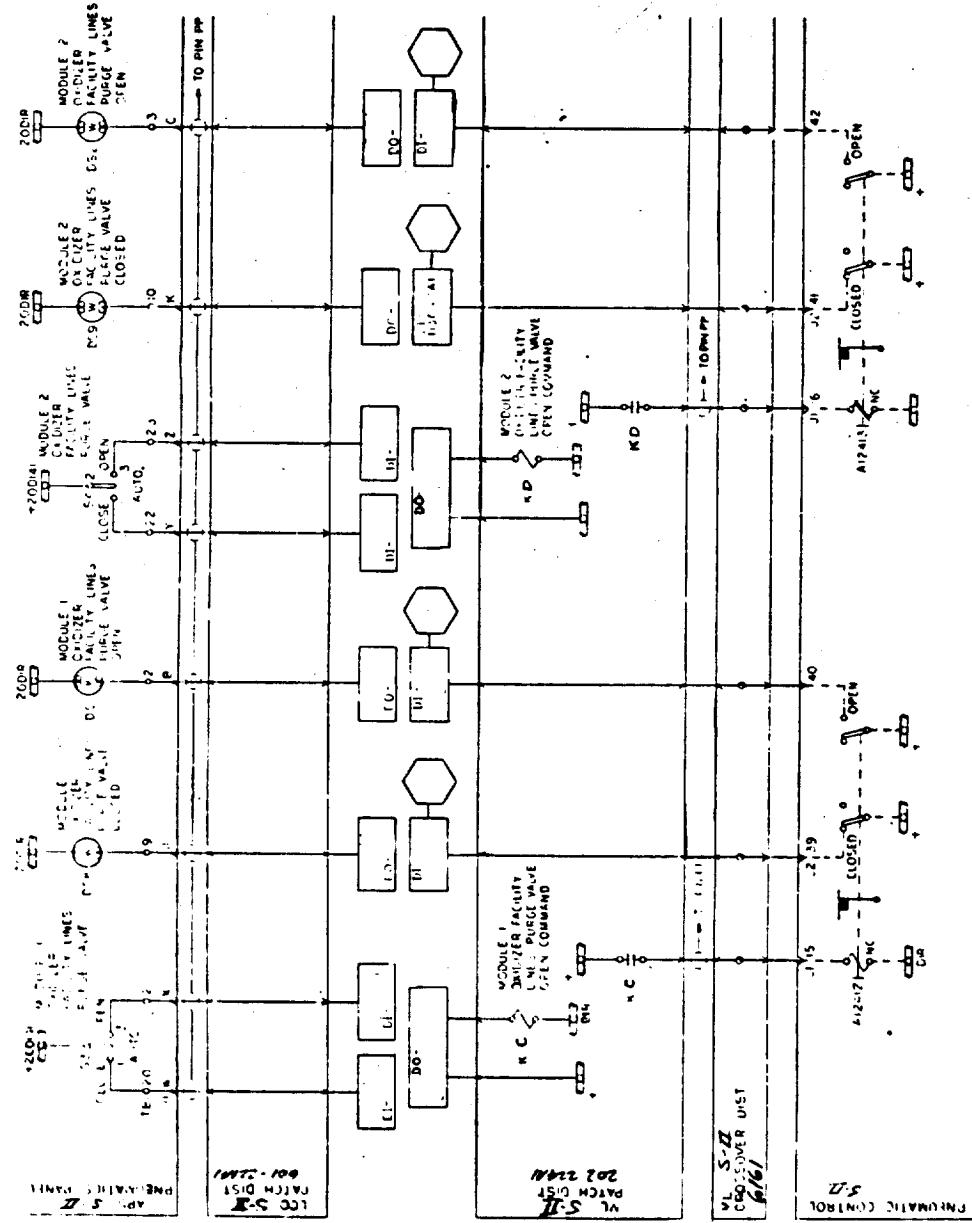


FIGURE 7-16 - NEW S-II AIPS PNEUMATIC ESE

SHEET 82  
SHEET 5

NUMBER D5-16793  
REV LTR

THE BOEING COMPANY

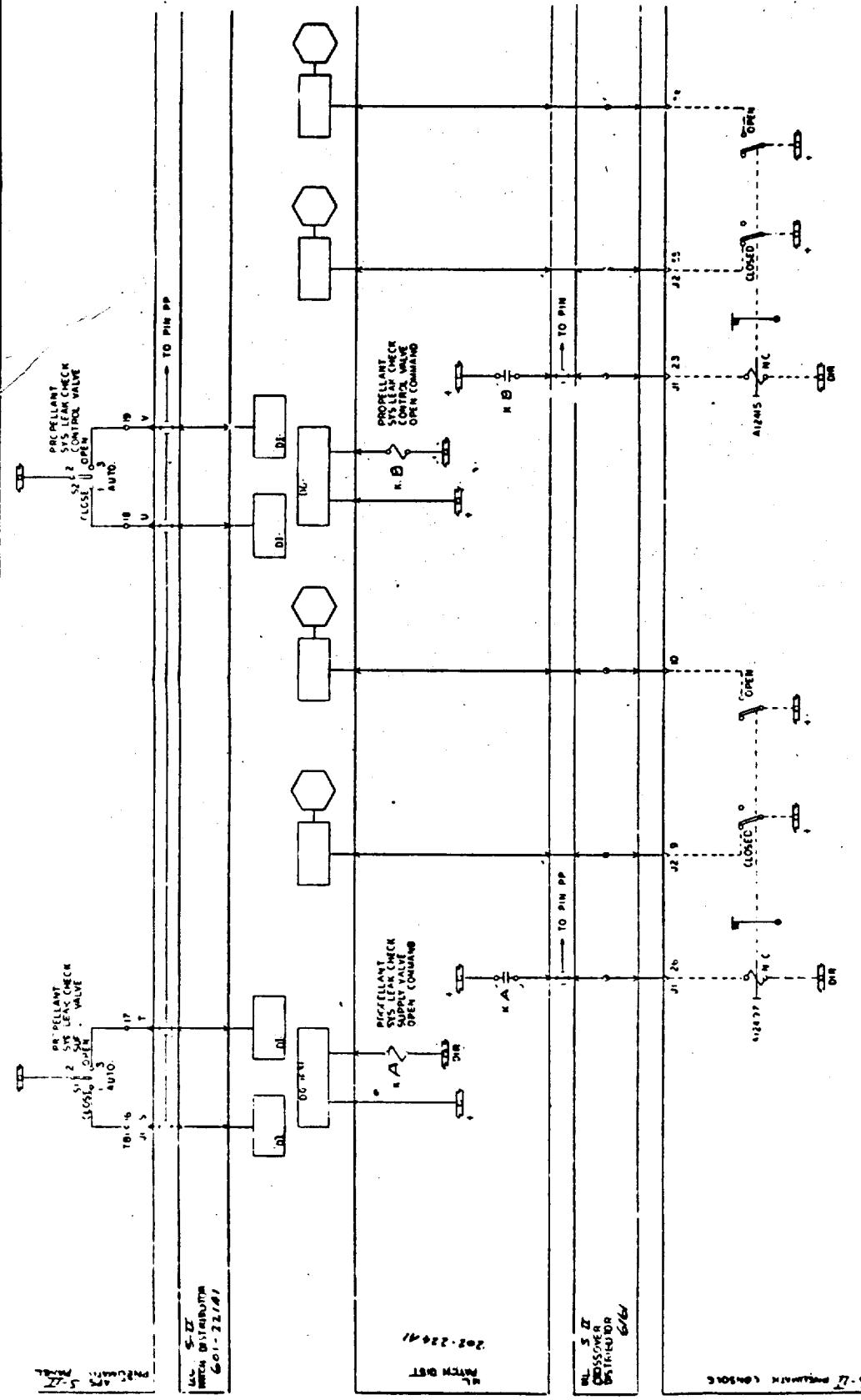


FIGURE 7-16 - NEW S-II APS PNEUMATIC ESE

SHEET 6

SHEET 83

D5-15793  
NUMBER  
REV LTR

THE MORGAN COMPANY

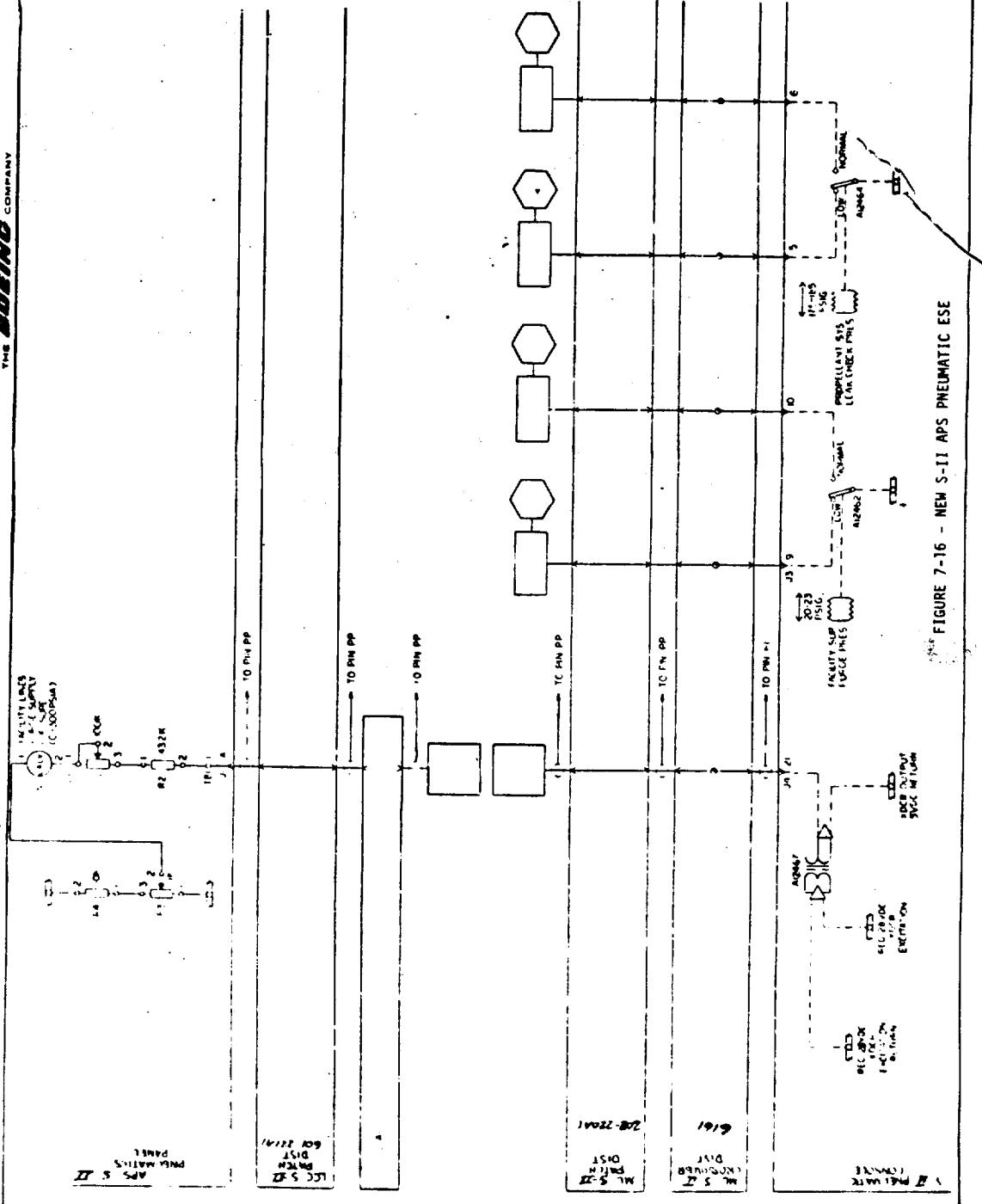


FIGURE 7-16 - NEW S-11 APS PNEUMATIC ESE

卷之三

CHSET 84

NUMBER D5-16793  
REV LTR

THE BOEING COMPANY

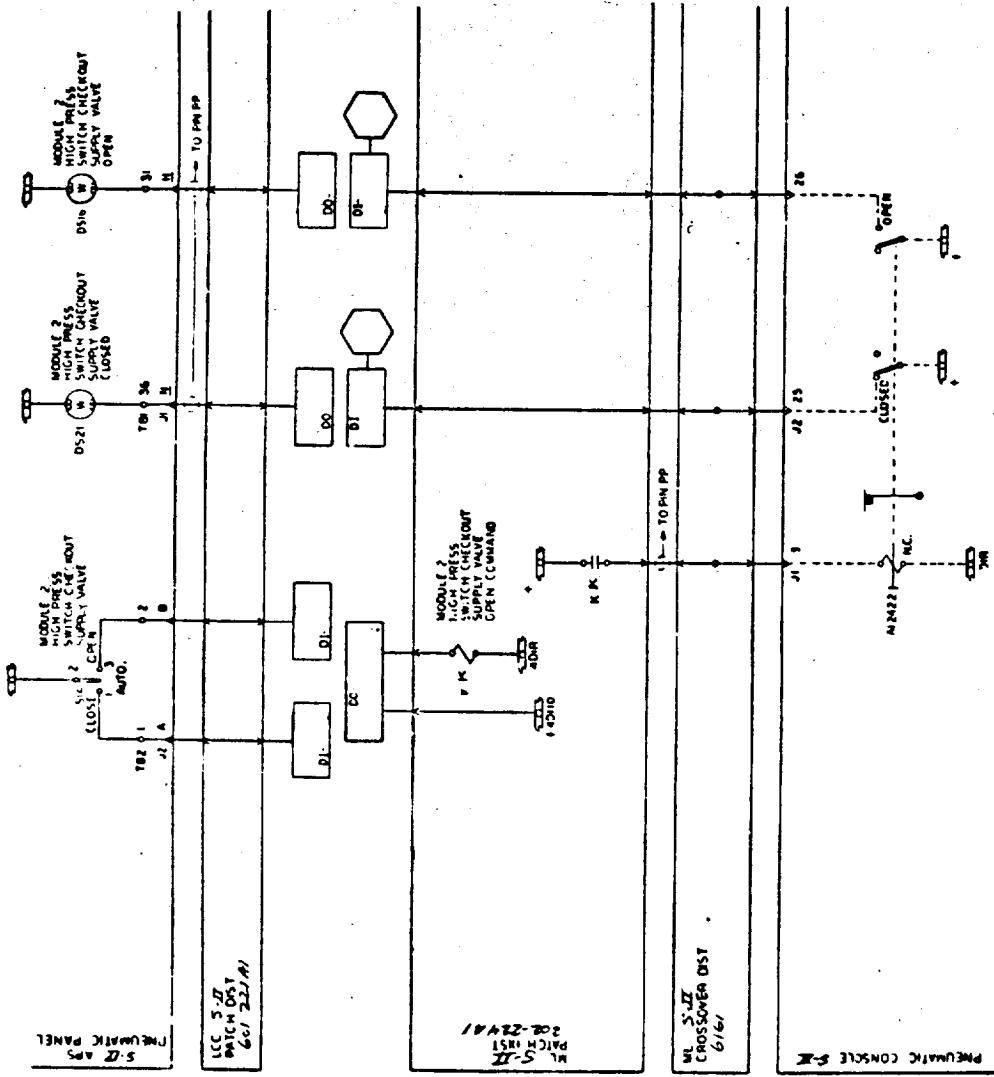


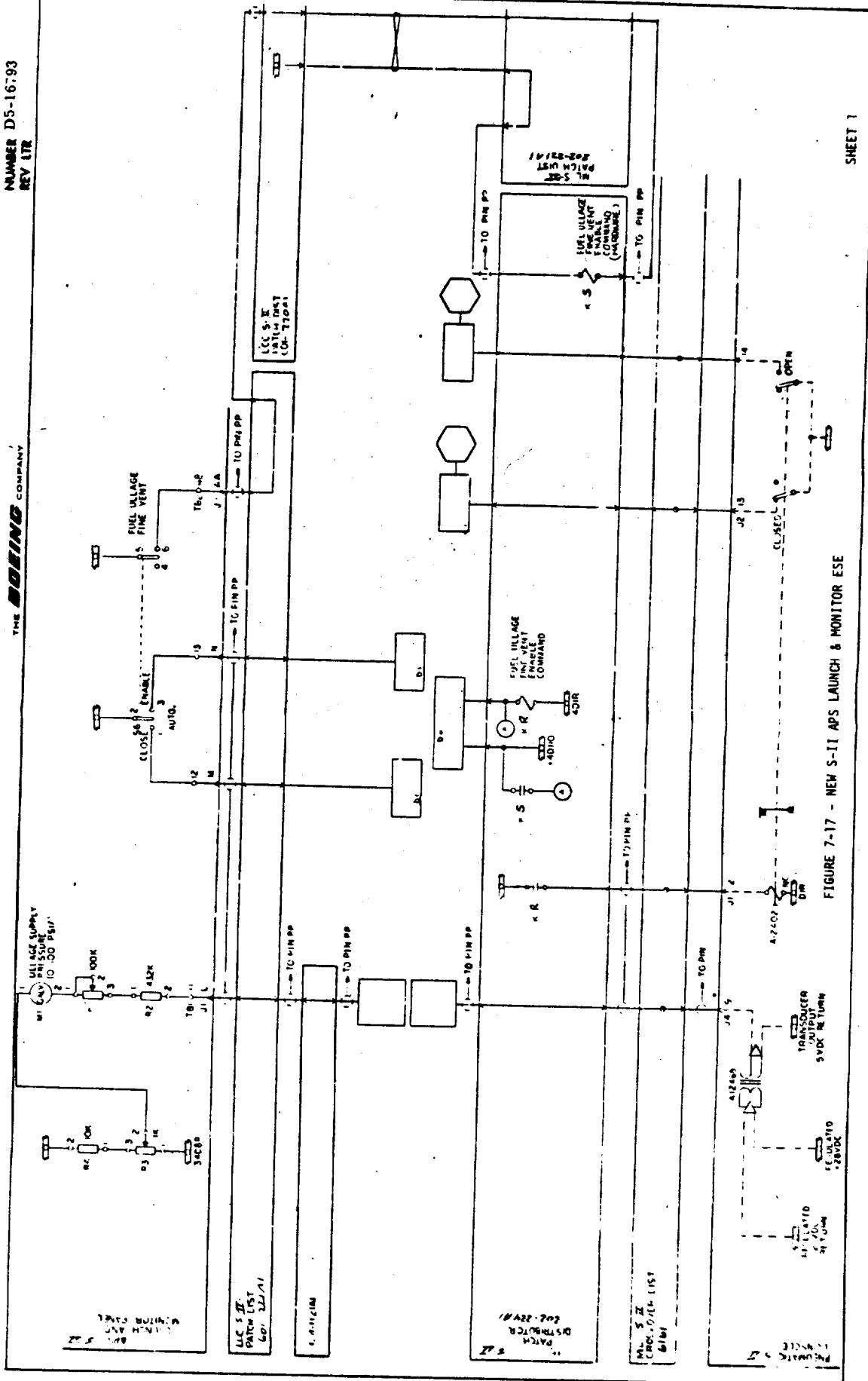
FIGURE 7-16 - NEW S-II APS PNEUMATIC ESE

SHEET 8

SHEET 85

THE BOEING COMPANY

NUMBER D5-16793  
REV LTR



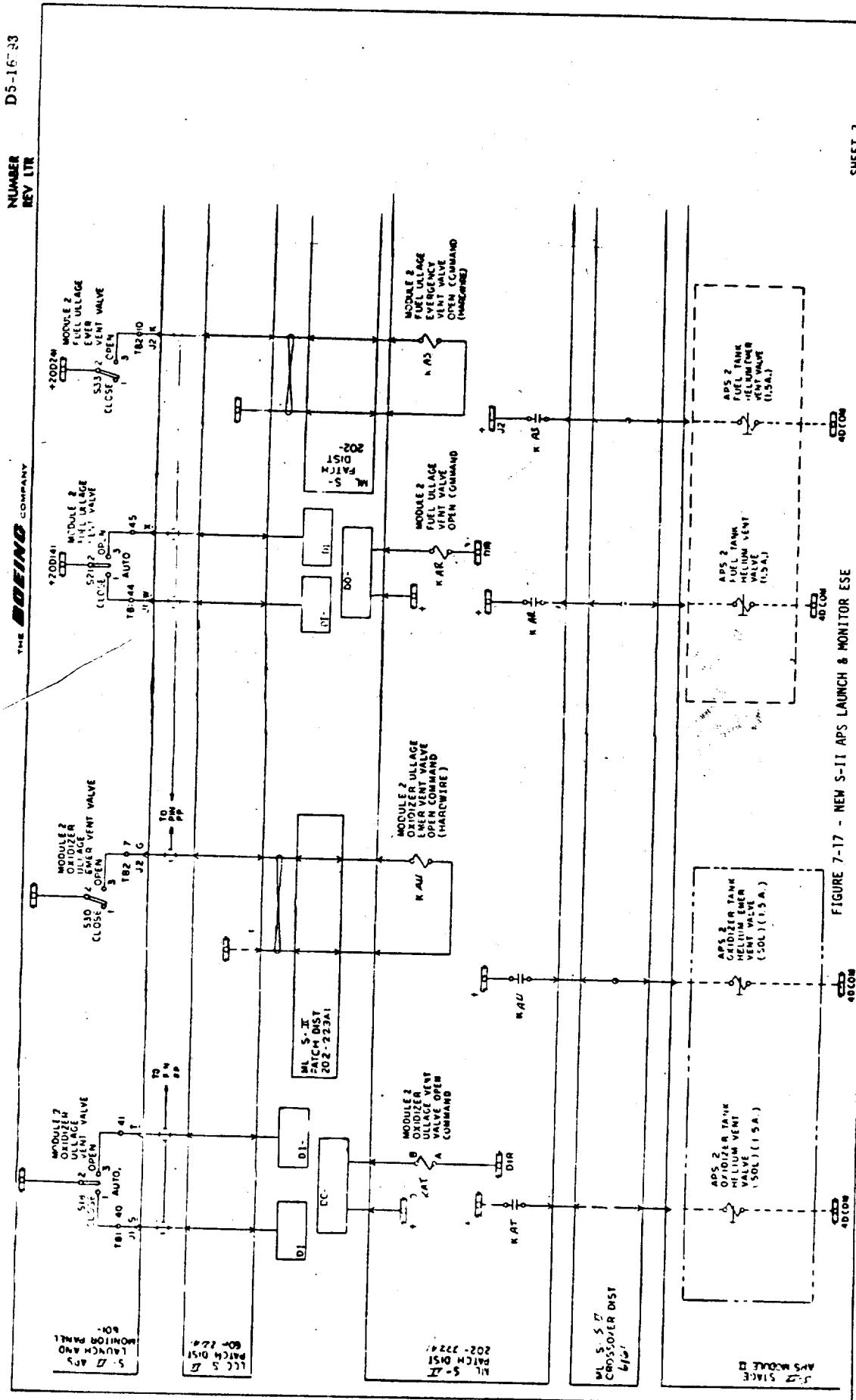


FIGURE 7-17 - NEW S-II APS LAUNCH &amp; MONITOR ESE

NUMBER 0-11793  
REV LTR

THE BOEING COMPANY

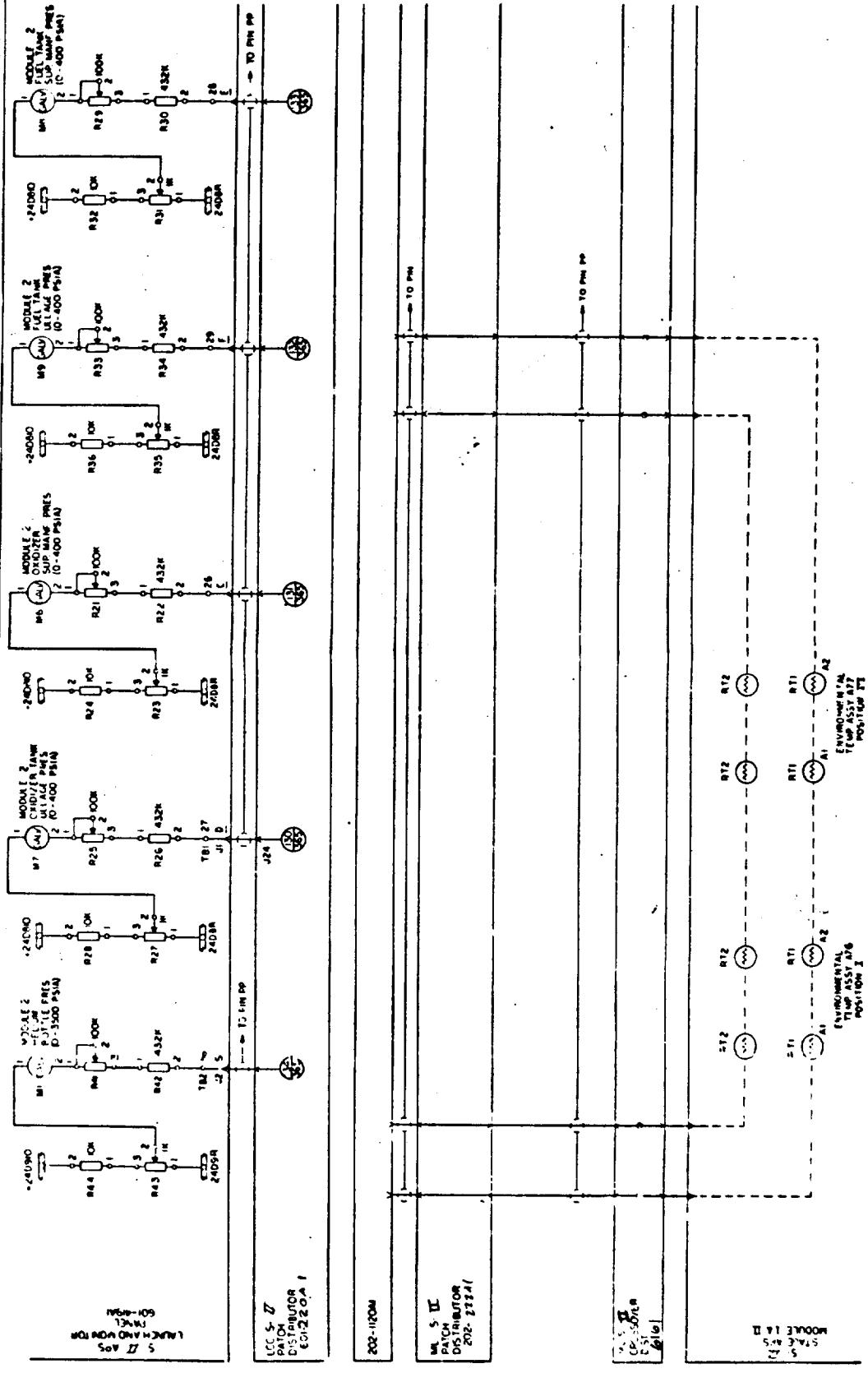


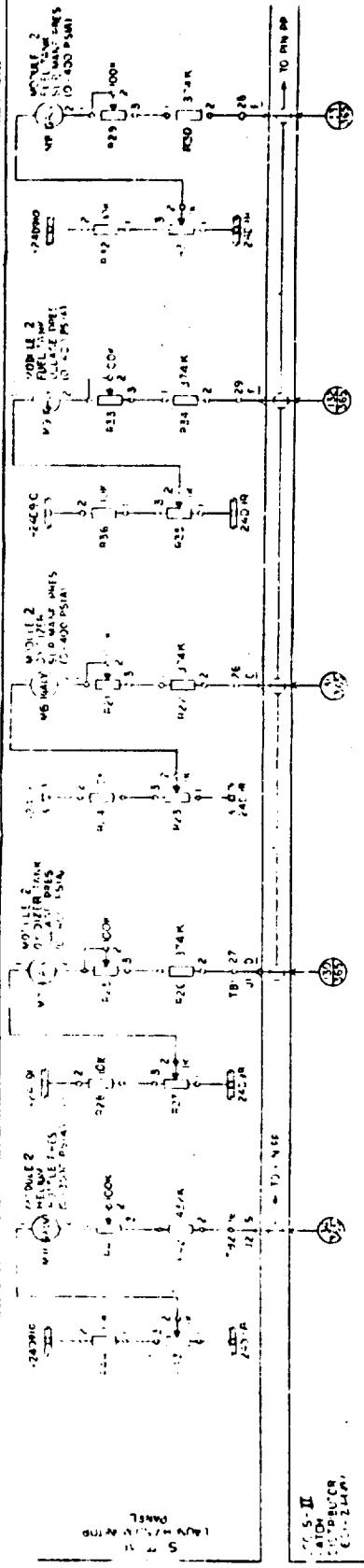
FIGURE 7-17 - NEW S-1 APS LAUNCH & MONITOR ESE

SHEET 3

SHEET 88

NUMBER J-17-5793  
REV LTR

THE BOEING COMPANY



222-1-203A

222-1-203A

MODULE 1A  
STAGE 2  
MS-10  
MISSILE  
SYSTEM

MODULE 1A  
STAGE 2  
MS-10  
MISSILE  
SYSTEM

NEW S-II  
APS Launch &  
Monitor ESE

FIGURE 7-17 - NEW S-II APS LAUNCH & MONITOR ESE

SHEET 4

SHEET 89

NUMBER D5-16-95  
REV LTR

THE BOEING COMPANY

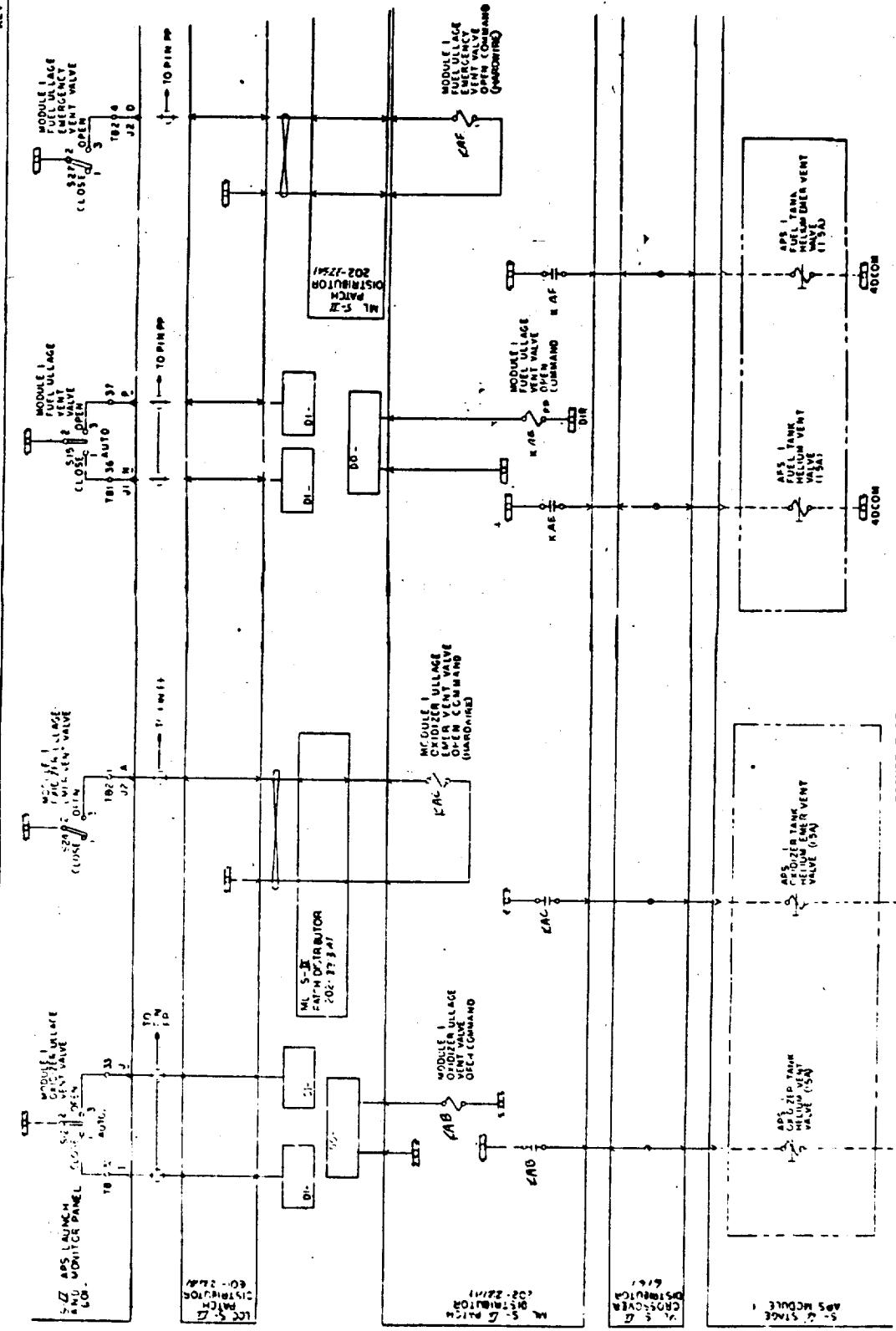
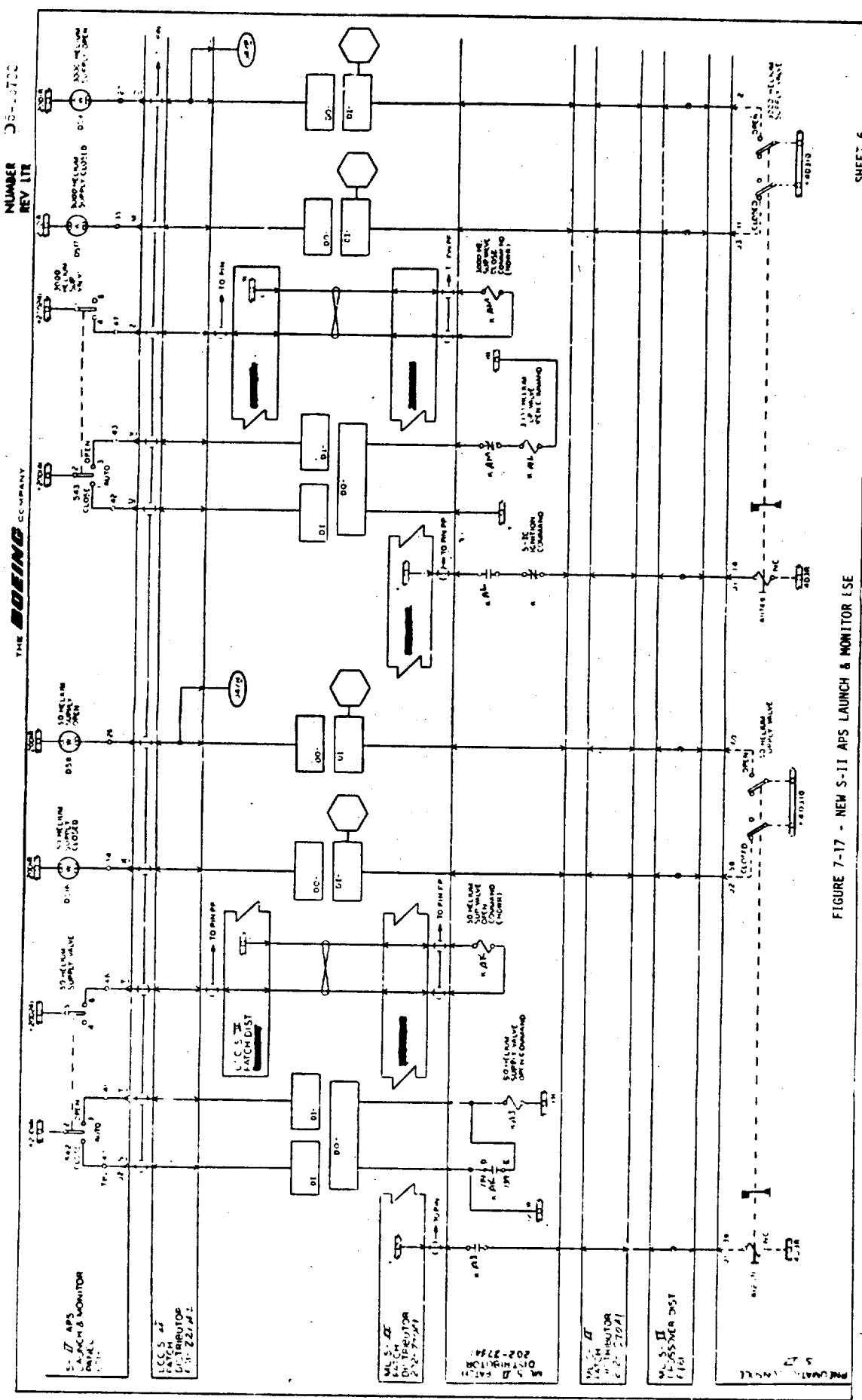


FIGURE 7-17 - NEW S-II PPS LAUNCH & MONITOR ESE

SHEET 5

SHEET 9

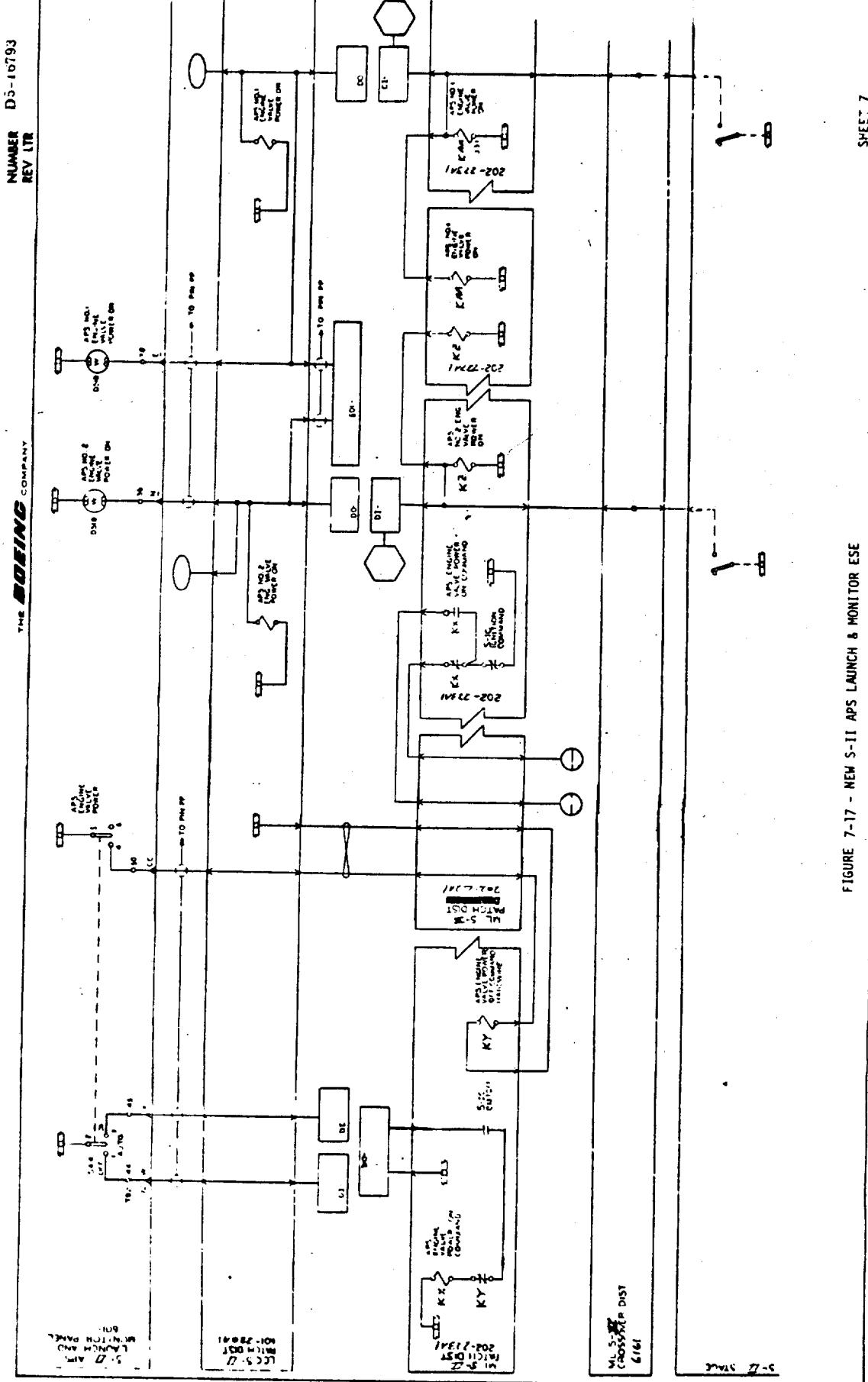
FIGURE 7-17 - NEW S-11 APS LAUNCH &amp; MONITOR ESE



SHEET 7

SHEET 92

FIGURE 7-17 - NEW S-II APS LAUNCH & MONITOR ESE



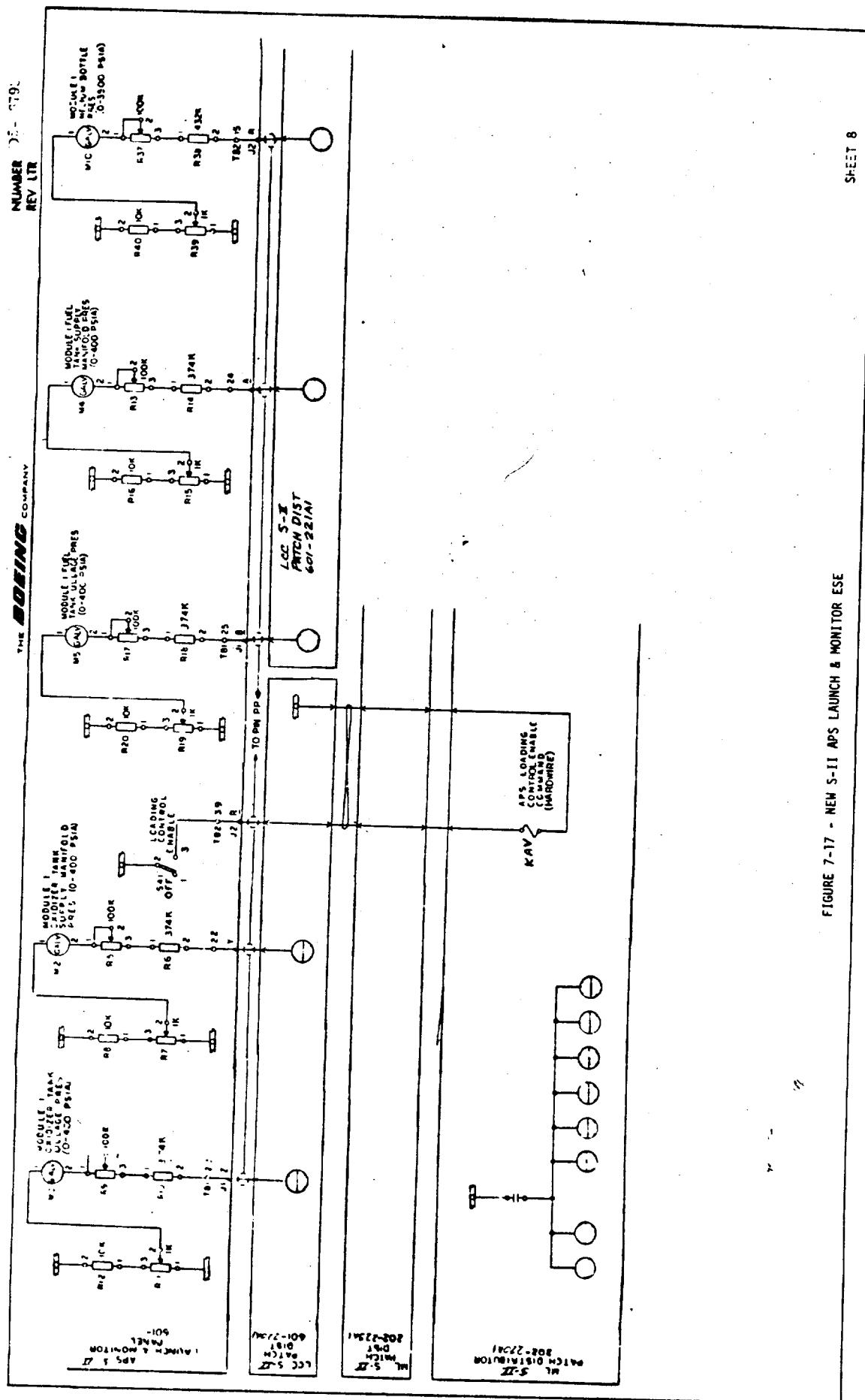


FIGURE 7-17 - NEW S-II APS LAUNCH & MONITOR ESE

NUMBER D5-16793  
REV LTR

THE BOEING COMPANY

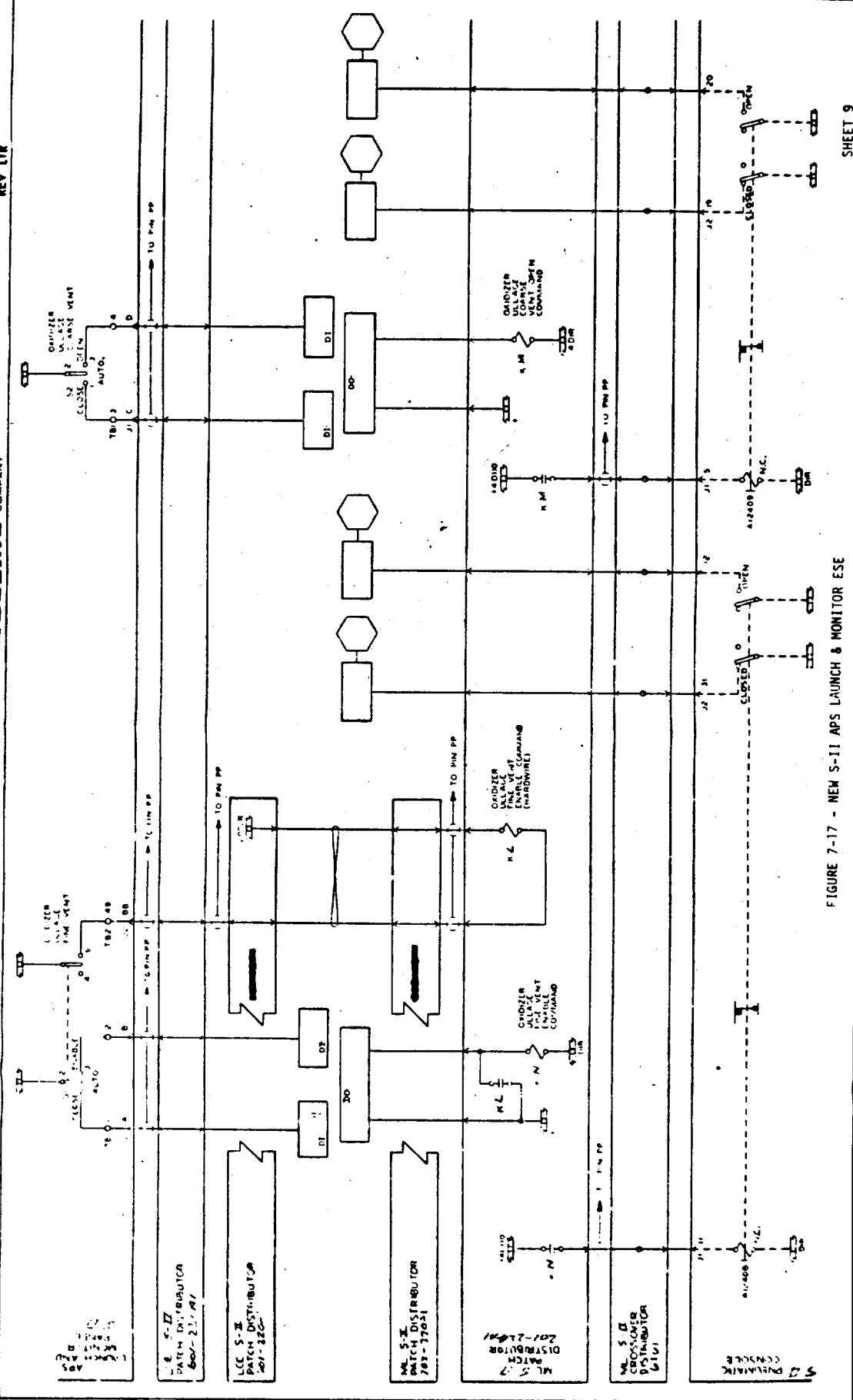
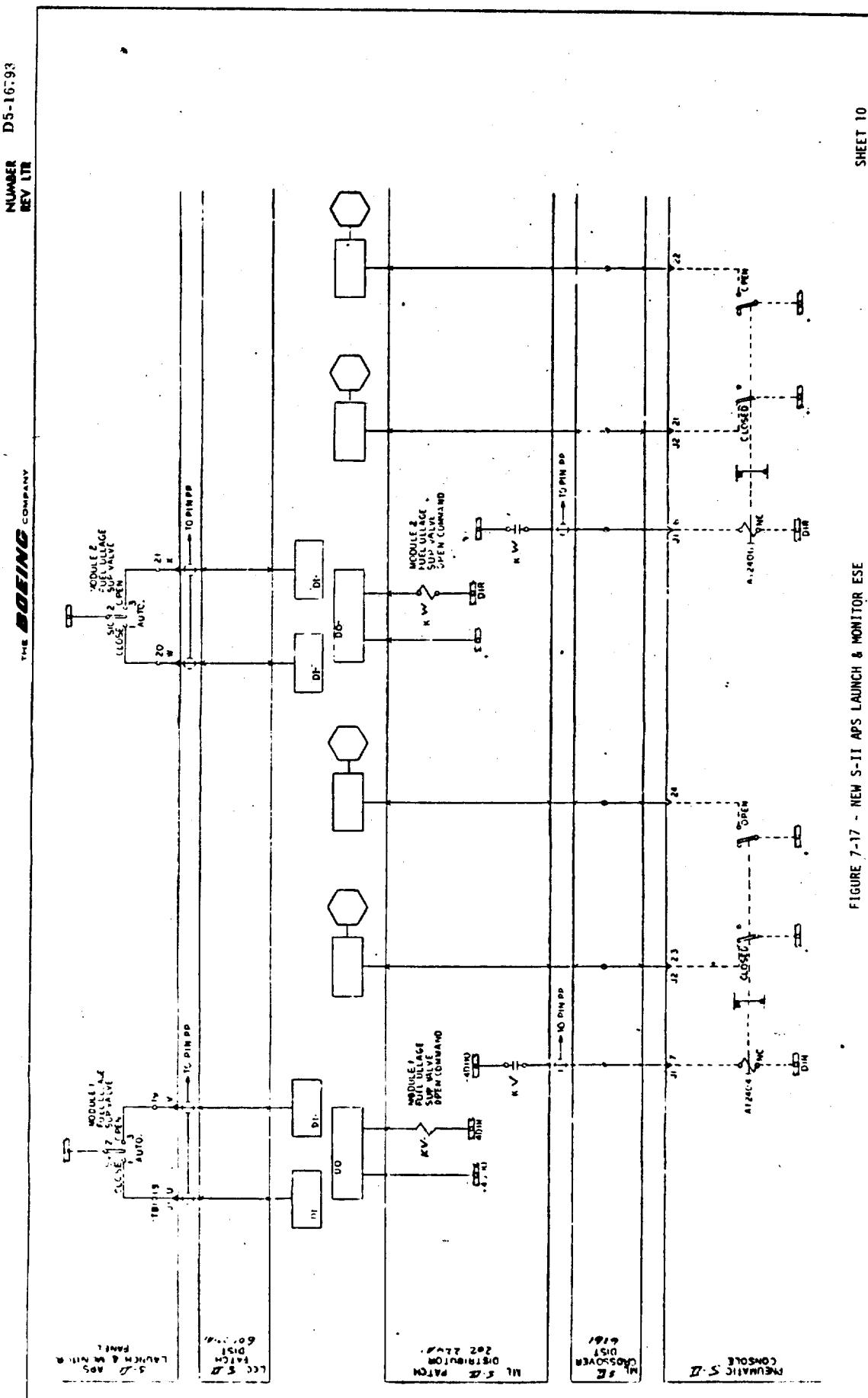


FIGURE 7-17 - NEW S-II APS LAUNCH & MONITOR ESE

FIGURE 7-17 - NEW S-II APS LAUNCH &amp; MONITOR ESE



NUMBER D5-16793

REV LTR

THE BOEING COMPANY

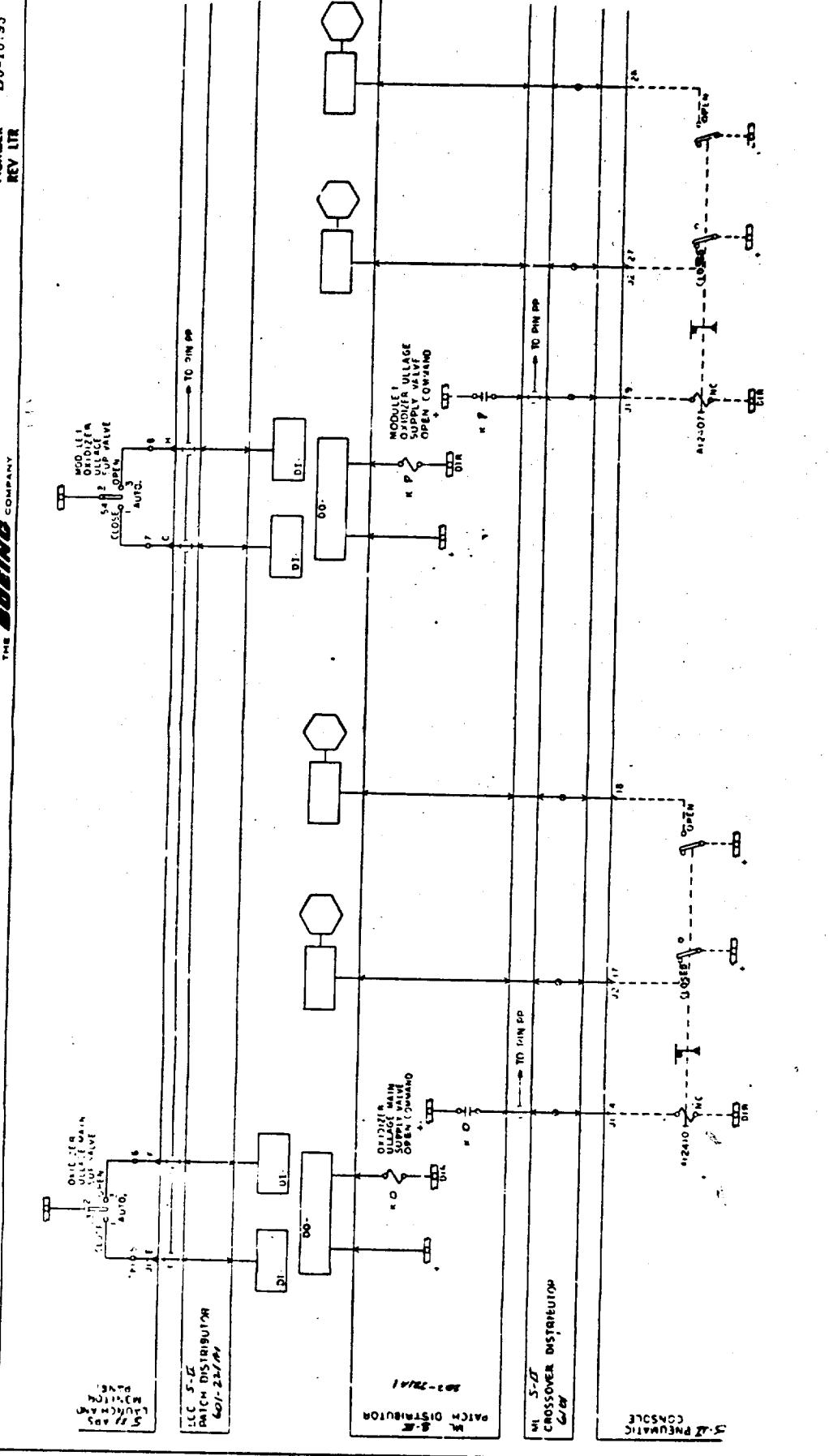


FIGURE 7-17 - NEW S-II APS LAUNCH & MONITOR ESE

SHEET 11

SHEET 96

NUMBER D5-16793  
REV LTR

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LAUNCH AND MONITOR  
PANEL

LCC 3-A  
DISPATCH  
DISPATCH

ML 6-A  
DISPATCH  
DISPATCH

ML 5-A  
CROSSOVER  
CROSSOVER

PNEUMATIC  
PNEUMATIC

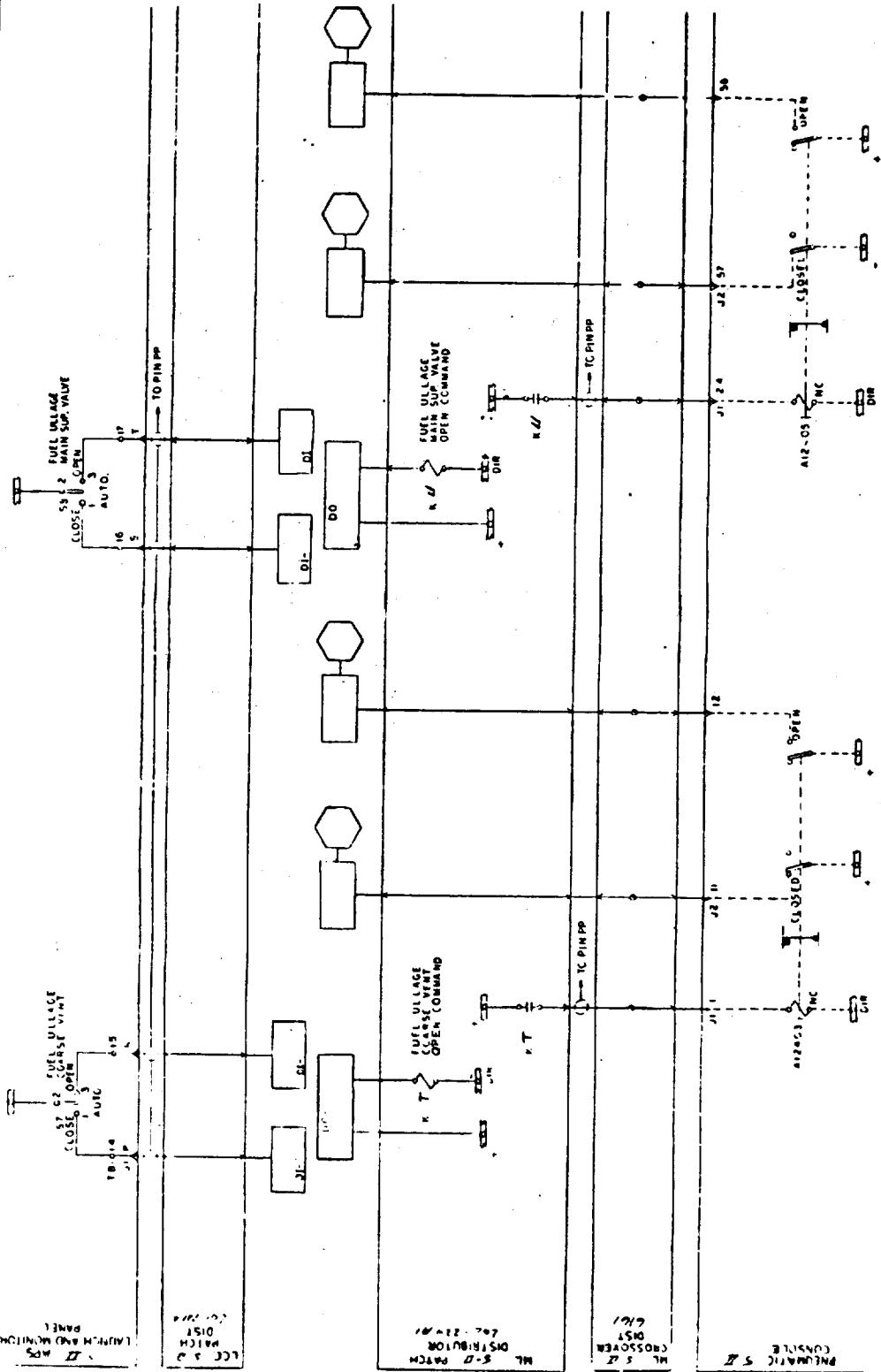


FIGURE 7-17 - NEW S-II APS LAUNCH & MONITOR ESE

SHEET 12

SHEET 97

NUMBER D5-16793  
REV LTR

THE BOEING COMPANY

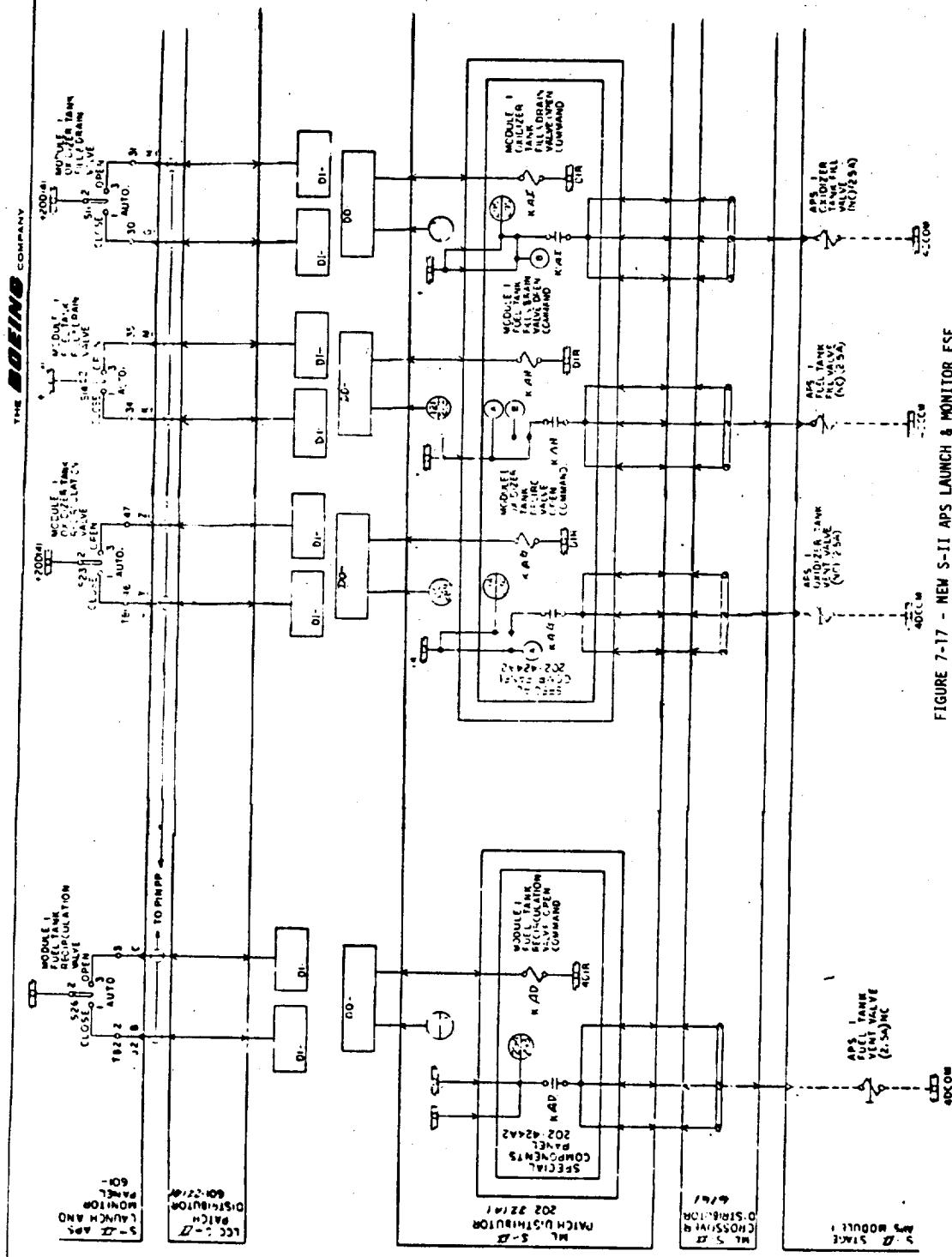


FIGURE 7-17 - NEW S-II APS LAUNCH & MONITOR ESE

SHEET 13

SHEET 98

NUMBER D5-16793  
REV LTR

THE BOEING COMPANY

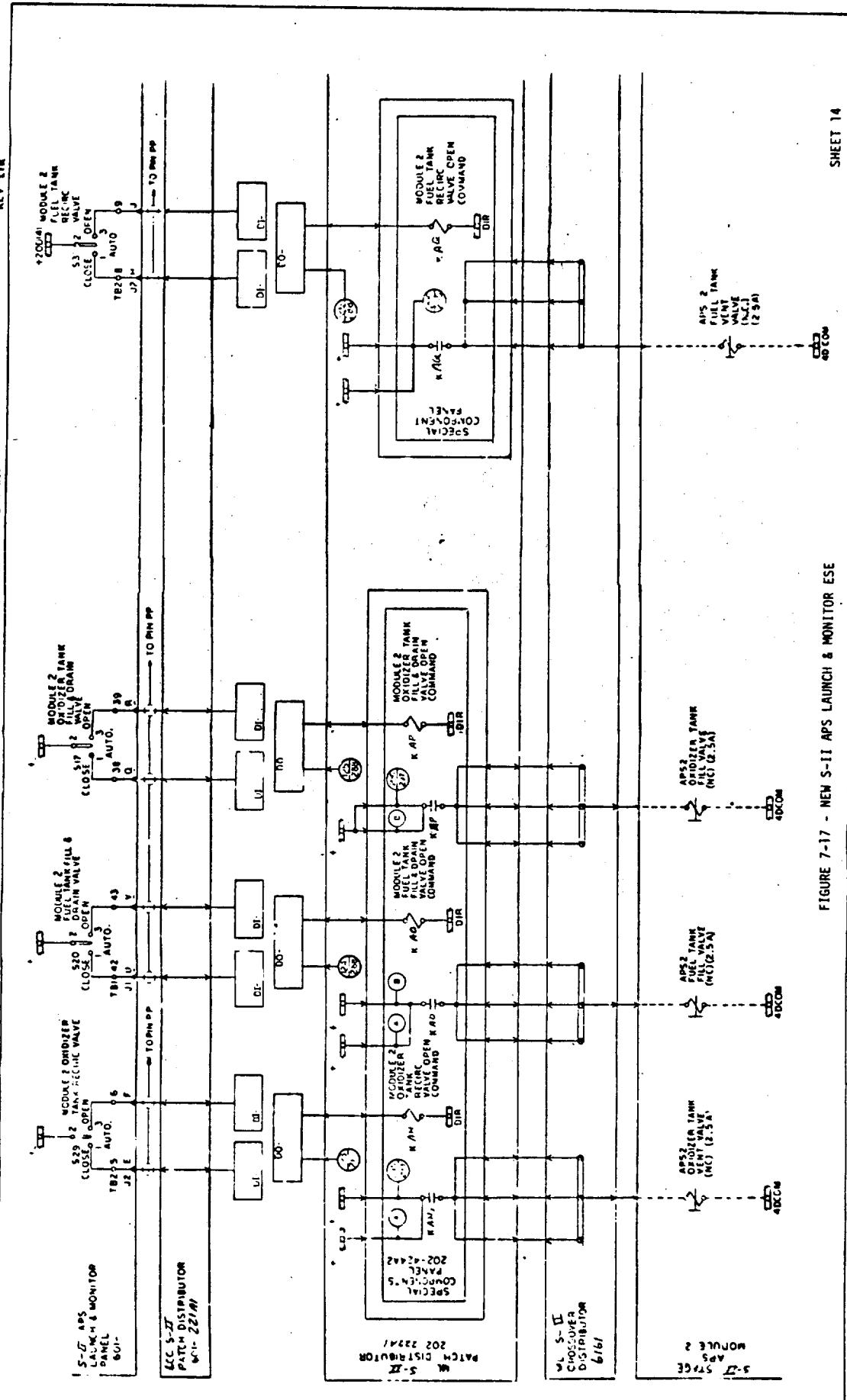


FIGURE 7-17 - NEW S-II APS LAUNCH & MONITOR ESE

SHEET 14

SHEET 89

NUMBER D5-16793  
REV LTR

THE BOEING COMPANY

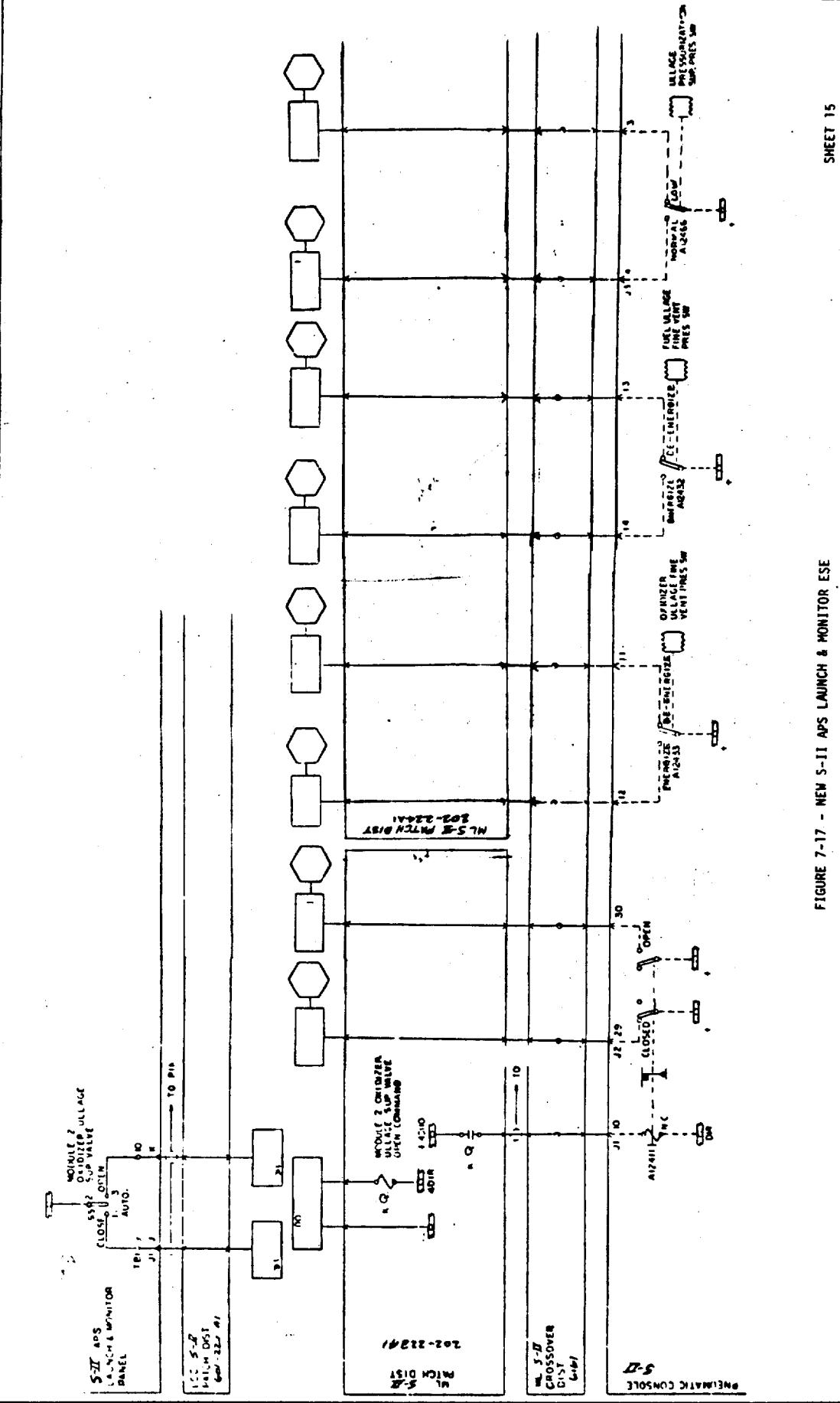


FIGURE 7-17 - NEW S-II APS LAUNCH & MONITOR ESE

SHEET 100  
SHEET 15

SDD 259 LOX TANK INTERNAL  
ACCESS KIT MOD FOR LEO MISSION

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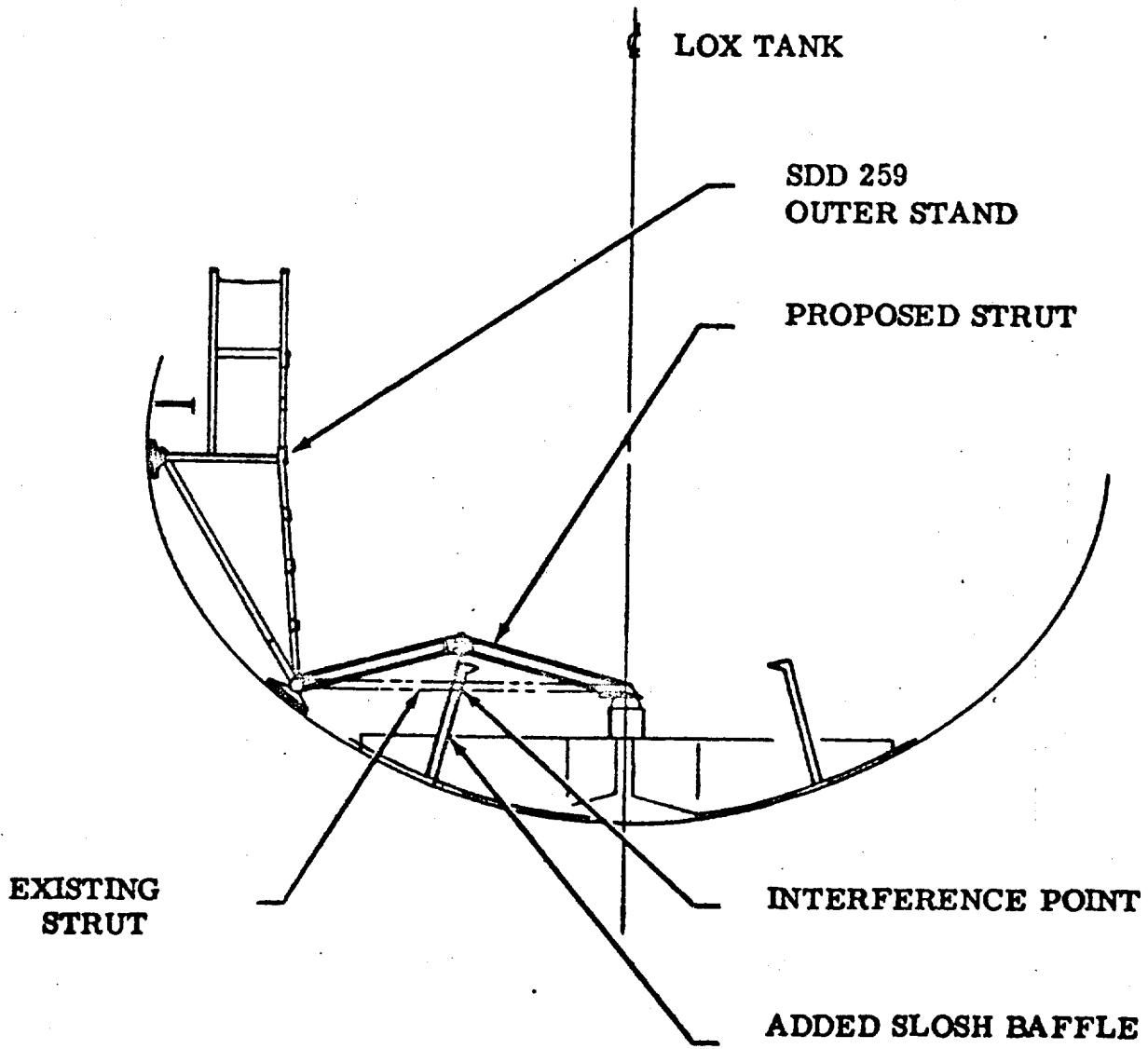


FIGURE 7-18

## 8.0

SCHEDULE

The implementation schedule is shown in Figure 8-1. Differences in implementation between LEO and LOR missions will produce changes to crew sizes and numbers of crews but will not produce significant changes in schedule flow time.

The implementation phase is to be broken into three parts: design, modification, and activation. Modification shall include teardown, deactivation, fabrication, installation, and reassembly. Activation shall include test, checkout, calibration, and buy-off of the completed modification. The implementation phasing will be keyed to vehicle design releases and stage on dock dates provided by MSFC. The phasing will be done in a manner that provides maximum assurance that vehicle interfaces are defined and established prior to start of GSE design; and which will provide completed GSE/facility modification prior to first J-2S stage on dock.

In developing the implementation schedule, schedule flow times for design, modification, and activation were established using the manhour estimates presented in Section 9. The manhour estimates and flow times were combined in a manner which established a realistic crew size for accomplishment of the design, modification, and activation. In order to reduce the modification and activation flow time, maximum consideration was given to accomplishing functions in parallel. The schedule shown in Figure 8-1 represents only one possible combination of manhours, flow times, functional sequences, and crew sizes and, therefore, must be considered as a representative schedule only.

## PROGRAM IMPLEMENTATION SCHEDULE S-II AND S-IVB WITH J-2S ENGINES

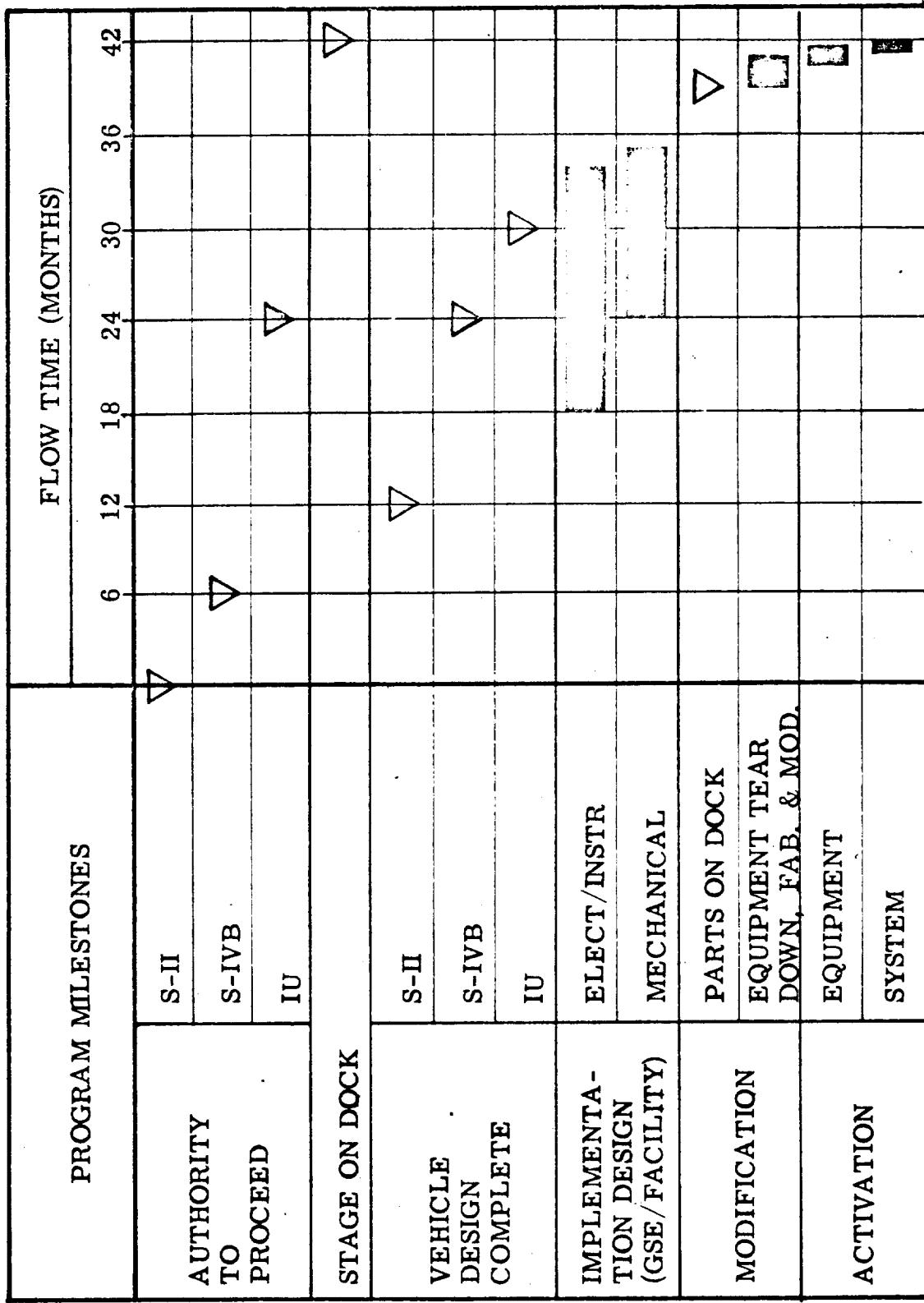


FIGURE 8-1

## 9.0

IMPLEMENTATING AND OPERATING COSTS

Cost data has been defined in two distinct categories - implementation (non-recurring) costs and Operating (recurring) costs. Implementation costs have been estimated for the facility and equipment changes defined in Section 7.0 of this document. Operating costs have been estimated for the processing operation changes as defined in Section 6.0.

## 9.1

## IMPLEMENTATION COSTS

Implementation (non-recurring) costs are shown for each mission. All costs are segregated into Design, Modification/Installation, and Activation (test and checkout) functions and as required to a lower level of detail. An Implementation Cost Summary for all projected vehicle combinations (LOR, LEO, and Synchronous Missions) is presented in Table 9-1 and 9-2. Costs for the LOR Mission are summarized on Table 9-3. Lower level of detail is on Tables 9-4 through 9-6. Cost summarization for the LEO Mission is on Table 9-7 and with the lower level of detail on Tables 9-8 through 9-10. Delta costs for LEO Mission assume the modifications for the LOR Mission have been completed. These delta costs are displayed on Table 9-11.

LEO Implementation Costs are limited to the costs resulting from the addition of J-2S engines and from S-II stage changes related to the LEO Mission. No attempt was made to determine the costs reduction due to the elimination of the S-IVB stage or the addition of an S-IVB workshop.

Synchronous Mission Costs are not included because the S-II stage is the same as the LOR and the S-IVB for this mission is only changed by the additions of Solid Propellant Turbo Starter (SPTS).

All costs have been based on historical and empirical data concerning similar facilities at Kennedy Space Center and Cape Kennedy. These costs represent an Industry average assuming calendar year 1969 rates and factors less any overtime considerations.

Further definition of the estimating can be found in Appendix F of this document.

## 9.2

## CHANGES IN RECURRING OPERATIONS COSTS

The changes in Operations Costs result from increases or reductions in operations due to the vehicle changes described in 5.0. These costs were developed by reviewing the operating procedures and estimating the percentage change due to a particular stage/vehicle modification. This percentage was applied to the time required to perform an operation as stated in each operating procedure with an assumed crew loading. The costing ground rules used in this study are identified in Table 9-12.

The results summarized in Table 9-12 and detailed in Appendix F show that a LOR vehicle can be processed through KSC with a reduction in crew size of 3.7 - men and 3,552 fewer manhours than the AS-503 vehicle. A LEO vehicle will result in a reduction in crew size of 2.3 - men and 2,238 manhours. This represents approximately 10 percent reduction in operations for a LOR vehicle and a 6 percent reduction for a LEO vehicle.

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**IMPLEMENTATION COST SUMMARY**  
**NON-RECURRING COST**

	Design	Modification/Installation	Activation	Total
S-IVB, One Restart - S-II No Restart (Ref. 6.1) - (LOR)	\$323,100	\$410,000	\$87,600	\$820,700
S-IVB, Two Restart - S-II No Restart (Ref. 6.2) (Synchronous Mission, Insignificant Cost Impact to the LOR Concept)				
S-II, One Restart - No S-IVB Stage (Ref. 6.3) - (LEO)	\$252,900	\$431,000	\$92,500	\$776,400

IMPLEMENTATION COST SUMMARY  
S-II DELTA COST

MISSION	VEHICLE	DESIGN	MODIFICATION INSTALLATION	ACTIVATION	TOTAL
LOR	S-II	\$165,700	\$219,000	\$47,700	\$432,400
	S-IVB	\$157,400	\$191,000	\$39,900	\$388,300
<b>TOTAL LOR</b>		<b>\$323,100</b>	<b>\$410,000</b>	<b>\$87,600</b>	<b>\$820,700</b>
LEO	S-II	\$252,900	\$431,000	\$92,500	\$776,400
<b>S-II DELTA COST</b>		<b>\$ 87,200</b>	<b>\$212,000</b>	<b>\$44,800</b>	<b>\$344,000</b>

These LEO mission costs include S-II LOR costs plus S-II Mission Peculiar Changes.

These S-II Delta costs are associated with the S-II LEO Mission Peculiar Changes only and represent delta costs to the LOR mission based on the assumption that KSC modifications for the LOR had already been completed. S-IVB deletion costs and S-II LOR costs are not included.



IMPLEMENTATION COST SUMMARY  
(NON-RECURRING COST)

S-IVB, One Restart - S-II, No Restart (LOR)

Facility/Equipment	Design	Modification Installation	Activation
<u>Mechanical</u>			
S-II	\$31,100	\$37,000	\$6,700
S-IVB	\$19,000	\$27,000	\$5,400
<u>Electrical</u>			
S-II	\$104,900	\$182,000	\$41,000
S-IVB	\$ 76,900	\$164,000	\$34,500
Procedure Changes			
S-III	\$29,700		
S-IVB	\$61,500		
<b>TOTAL</b>	<b><u>\$323,100</u></b>	<b><u>\$410,000</u></b>	<b><u>\$87,600</u></b>

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Table 9-3

IMPLEMENTATION - NON-RECURRING  
DESIGN

S-IVB, One Restart - S-II, No Restart (LOR)

<u>Facility/Equipment</u>	<u>Manhours</u>	<u>Total Dollars</u>
<u>Mechanical - Mobile Launcher</u>		
S-II	2,395	\$ 31,100
S-IVB	1,465	\$ 19,000
<u>Electrical</u>		
S-II		
Mobile Launcher	2,666	\$ 34,600
Launch Control Center	5,412	\$ 70,300
S-IVB		
Mobile Launcher	1,954	\$ 25,400
Launch Control Center	3,966	\$ 51,500
<u>Procedure Changes</u>		
(Nonrecurring costs brought forward from Operations costs)		
S-II	2,284	\$ 29,700
S-IVB	4,735	\$ 61,500
<u>TOTAL</u>	<u>24,877</u>	<u>\$323,100</u>

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Table 9-4

IMPLEMENTATION - NON-RECURRING  
MODIFICATION/INSTALLATION

S-IVB, One Restart - S-II, No Restart (LOR)

<u>Facility/Equipment</u>	<u>Manhours</u>	<u>Labor Dollars</u>	<u>Material Dollars</u>	<u>Total Dollars</u>
<u>Mechanical</u>				
S-II - Mobile Launcher				
S7-41A	1,512	\$ 18,000	\$ 19,000	\$ 37,000
S7-41B				
S7-41C				
A7-71				
Umbilical Mods				
S-IVB - Mobile Launcher				
432-A	\$ 1,028	\$ 13,000	\$ 14,000	\$ 27,000
433-A				
438-A				
<u>Electrical</u>				
S-II				
Launch Control				
Center	9,447	\$113,000	\$ 11,000	\$24,000
Mobile Launcher	4,424	\$ 53,000	\$ 5,000	\$ 58,000
S-IVB				
Launch Control				
Center	8,016	\$ 96,000	\$ 10,000	\$106,000
Mobile Launcher	4,424	\$ 53,000	\$ 5,000	\$ 58,000
<b>TOTAL</b>	<b><u>28,851</u></b>	<b><u>\$346,000</u></b>	<b><u>\$ 64,000</u></b>	<b><u>\$410,000</u></b>

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IMPLEMENTATION - NON-RECURRING  
ACTIVATION

S-IVB, One Restart - S-II, No Restart (LOR)

<u>Facility/Equipment</u>	<u>Manhours</u>	<u>Total Dollars</u>
<b>Mechanical - Mobile Launcher</b>		
S-II - GSE/FSE	570	\$ 6,700
S-IVB - GSE/FSE	458	\$ 5,400
<b>Electrical</b>		
<b>S-II</b>		
Mobile Launcher	1,156	\$13,700
Launch Control Center	2,310	\$27,300
<b>S-IVB</b>		
Mobile Launcher	1,156	\$13,700
Launch Control Center	1,757	\$20,800
<b>TOTAL</b>	<u>7,407</u>	<u>\$87,600</u>

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Table 9-6

**IMPLEMENTATION COST SUMMARY  
(NON-RECURRING COST)****S-II, One Restart - No S-IVB Stage - (LEO)**

Facility/Equipment	Design	Modification Installation	Activation
<b>Mechanical - Structural</b>			
S-II	\$ 55,300	\$217,000	\$44,600
<b>Electrical</b>			
S-II	\$139,300	\$214,000	\$47,900
<b>Procedures</b>	<b>\$ 58,300</b>	<b>\$ -0-</b>	<b>\$ -0-</b>
<b>TOTAL</b>	<b><u>\$252,900</u></b>	<b><u>\$431,000</u></b>	<b><u>\$92,500</u></b>

USE FOR DRAWING AND HANDPRINTING — NO TYPED OR PRINTED MATERIAL

Table 9-7

IMPLEMENTATION - NON-RECURRING  
DESIGN

S-II, One Restart - No S-IVB Stage (LEO)

<u>Facility/Equipment</u>	<u>Manhours</u>	<u>Total Dollars</u>
<u>Mechanical - Structural</u>		
S-II Mobile Launcher	2,620	\$ 34,000
S-II Mobile Service Structure	1,640	\$ 21,300
<u>Electrical</u>		
S-II		
Mobile Launcher	3,538	\$ 46,000
Launch Control Center	7,182	\$ 93,300
Procedure Changes     S-II (Nonrecurring costs brought forward from Operations cost)	4,486	\$ 58,300
<b>TOTAL</b>	<b><u>19,466</u></b>	<b><u>\$252,900</u></b>

USE FOR DRAWING AND HANDPRINTING — NO TYPED OR PRINTED MATERIAL

Table 9-8

IMPLEMENTATION - NON-RECURRING  
MODIFICATION/INSTALLATION

S-II, One Restart - No S-IVB Stage (LEO)

Facility/Equipment	Manhours	Labor Dollars	Material Dollars	Total Dollars
<u>Mechanical</u>				
Mobile Launcher S7-41A, S7-41B, S7-41C, A7-71, Umbilical Mods	1,876	\$ 23,000	\$ 47,000	\$ 70,000
<u>Mobile Service Structure</u>				
APS Fuel & Oxidizer isolation valve boxes fuel & Oxidizer control assemblies. OIS Mods Safety Equipment GN2 Purge Sys. Mods	5,166	\$ 62,000	\$ 74,000	\$136,000
<u>Structural</u>				
<u>Mobile Service Structure</u>				
Pipe Chase and Catwalks	709	\$ 9,000	\$ 2,000	\$ 11,000
<u>Electrical</u>				
<u>S-II</u>				
Mobile Launcher	4,424	\$ 53,000	\$ 5,000	\$ 58,000
Launch Control Center	11,809	\$142,000	\$ 14,000	\$156,000
<b>TOTAL</b>	<b><u>23,984</u></b>	<b><u>\$289,000</u></b>	<b><u>\$142,000</u></b>	<b><u>\$431,000</u></b>

USE FOR DRAWING AND HANDPRINTING - NO TYPED WRITTEN MATERIAL

**IMPLEMENTATION - NON-RECURRING  
ACTIVATION****S-II, One Restart - No S-IVB Stage (LEO)**

<u>Facility/Equipment</u>	<u>Manhours</u>	<u>Total Dollars</u>
<b>Mechanical</b>		
S-II - GCL/FSE		
Mobile Launcher	1,258	\$14,800
Mobile Service Structure	2,515	\$29,800
<b>Electrical</b>		
S-II		
Mobile Launcher	1,156	\$13,700
Launch Control Center	2,888	\$34,200
<b>TOTAL</b>	<b><u>7,817</u></b>	<b><u>\$92,500</u></b>

USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL

Table 9-10

**IMPLEMENTATION COST SUMMARY**  
**(NON-RECURRING COST)**

**LEO DELTA COST**

Facility/Equipment	Design	Modification Installation	Activation
LEO S-II	\$227,400	\$431,000	\$92,500
LOR S-II	\$165,700	\$219,000	\$47,700
Delta Cost	\$ 61,700		
Procedures			
LEO S-II	\$ 25,500	\$212,000	\$44,800
	\$ 87,200		
Grand Total	<u><u>\$344,000</u></u>		

Table 9-11

**OPERATIONS COST SUMMARY****DELTA COST SUMMARY - LOR**

	One Vehicle	Two Vehicles
Base Line Hours	58,164	116,328
LOR Hours	54,612	109,224
Delta Hours	3,552	77,104
Delta Men (Crew)	3.7	3.7

**DELTA COST SUMMARY - LEO**

	One Vehicle	Two Vehicles
Base Line Hours	23,223	46,446
LEO Hours	20,985	41,970
Delta Hours	2,238	4,476
Delta Men (Crew)	2.3	2.3

**Ground Rules:**

1. Based on two vehicles per year.
2. Delta men (crew) based on a 12 month schedule @ 160 manhours per month.
3. Estimated total of 146 procedures are involved.
4. Base line hours based on Saturn V, vehicle 503 procedures.
5. Hours are the estimated hours required to perform the operations for the procedures involved, deletions, additions and change to the base line procedures.

10.0 RETROFIT

The J-2S Improvement Study - Retrofit Phase technical description contained in D5-15772-8 was reviewed to determine the impact on the data contained in Sections 6.0 through 9.0 of this document. This review resulted in identifying differences in implementing the in-line versus retrofit concepts; however, these differences were such that the KSC changes to GSE and procedures due to retrofit do not produce significant change to the in-line concept. Therefore, Launch Operations Changes (Section 6.0), Facilities and Equipment Modifications (Section 7.0), Schedule (Section 8.0) and Implementing and Operating Costs (Section 9) will remain unchanged for the retrofit program.

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**APPENDIX A**  
**VEHICLE PROCESSING OPERATIONS**

## APPENDIX A - VEHICLE PROCESSING OPERATIONS ITEM 1.9.1.1

PROCESSING FUNCTION	S-II with no restarts and S-IVB with 1 or 2 restarts (LOR and Sync Missions)	S-II with one restart ; No S-IVB (LEO Mission)			
	CHANGE	NO CHANGE	CHANGE	NO CHANGE	
PHASE I - LOW BAY OPERATIONS					
1. Conduct low bay ESE verification - S-II	X		X X		
2. Checkout and acceptance test the low bay pneumatics and fluid distribution system - S-II	X X		X X		
3. Conduct measurement station checkout - S-II		X		X	
4. Conduct continuity checks between LCC and LUT	X	X		X	
5. Transfer S-II to VAB low bay area		X X		X X	
6. Install S-II engine compartment heat shield protection set	X X		X X		
7. Install S-II engine compartment heat shield protection set		X X		X X	
8. Erect S-II in low bay cell		X X		X X	
9. Conduct S-II receiving inspection		X X		X X	
10. Install S-II access equipment		X X		X X	
11. Conduct S-II pre-power tests		X X		X X	
12. Checkout S-II instrumentation		X X		X X	
13. Power up S-II stage		X X		X X	
14. Checkout S-II leak detection GSE		X X		X X	
15. Conduct S-II leak tests		X X		X X	
16. Checkout S-II telemetry		X X		X X	
17. Checkout S-II range safety		X X		X X	
18. Checkout S-II thermal control system		X X		X X	
19. Verify S-II leak detection system		X X		X X	
20. Checkout S-II engines		X X		X X	
21. Prepare for transfer to High Bay - S-II		X X		X X	
22. Add S-II APS Checkout				NEW	NEW
23. Add S-II APS Installation				N/A	N/A
24. Conduct low bay ESE verification S-IVB				N/A	N/A
25. Checkout low bay pneumatics - S-IVB				N/A	N/A
26. Conduct instrumentation readiness check - S-IVB				N/A	N/A
27. Transfer S-IVB to VAB low bay area				X	N/A
28. Install S-IVB static dessicants					N/A

## APPENDIX A - VEHICLE PROCESSING OPERATIONS ITEM 1.9.1.1

PROCESSING FUNCTION	S-II with no restarts and S-IVB with 1 or 2 restarts (LOR and Sync Missions)	S-II with one restart : No S-IVB (LEO Mission)			
	CHANGE	NO CHANGE	CHANGE	NO CHANGE	
29. Install access equipment on S-IVB			N/A		
30. Erect S-IVB in low bay cell			N/A		
31. Install S-IVB access equipment			N/A		
32. Conduct receiving inspection on S-IVB			N/A		
33. Conduct umbilical impedance test - S-IVB	X		N/A		
34. Verify S-IVB instrumentation readiness	X		N/A		
35. Install umbilical - S-IVB			N/A		
36. Conduct stage logic reset			N/A		
37. Conduct power setups - S-IVB	X		N/A		
38. Conduct power distribution and control switchings S-IVB	X		N/A		
39. Verify chilldown load - S-IVB			DELETE		
40. Conduct propulsion system test Setups - S-IVB	X		N/A		
41. Conduct propulsion system tests - S-IVB	X		N/A		
42. Checkout APS module - S-IVB	X		N/A		
43. Install APS module - S-IVB	X		N/A		
44. Prepare for transfer to High Bay - S-IVB	X		N/A		
PHASE II - VEHICLE ERECTION					
45. Erect and checkout - S-IC			X		
46. Erect S-II on S-IC			X		
47. Hookup and verify S-II umbilical			X		
48. Conduct S-II ESE measurements compatibility checks	X		X		
49. Conduct S-IC/S-II interface verification tests			X		
50. Add S-II APS to vehicle interface checkout			X	NEW	
51. Checkout S-II thermal control systems			X	X	
52. Erect S-IVB on S-II			N/A	NEW	
53. Add erection of space station on S-II			N/A		
54. Checkout S-IVB/S-II electrical mating	X				

## APPENDIX A - VEHICLE PROCESSING OPERATIONS ITEM 1.9.1.1

PROCESSING FUNCTION	S-II with no restart S-IVB with 1 or 2 restarts (LOR and Sync Missions)	S-II with one restart No S-IVB (LEO Mission)			
	CHANGE	NO CHANGE	CHANGE	NO CHANGE	
55. Erect I. U.			X	X	X
56. Checkout I. U./S-IVB electrical mating			X	X	N/A
57. Hookup and verify S-IVB umbilical					N/A
58. Conduct S-IVB ESE Measurements compatibility checks			X	X	N/A
59. Conduct S-IVB APS to vehicle interface checkout					N/A
60. Conduct L/V electrical system preps			X	X	X
61. Add electrical mating of I. U. to space station					NEW
<b>PHASE III - L/V SUBSYSTEM CHECKS</b>					
62. Conduct L/V electrical systems verification test	X		X		X
63. Conduct S-II LCC meter and recorder calibration	X		X		X
64. Conduct S-IVB LCC meter and recorder calibration	X				N/A
65. Conduct S-IVB power distribution and control switching test	X		X		N/A
66. Conduct S-IVB DDAS subsystem test	X		X		N/A
67. Conduct S-IVB engine ECS test	X		X		N/A
68. Conduct S-IVB measurements verification	X		X		N/A
69. Checkout S-IVB hydraulics	X		X		N/A
70. Checkout S-IVB APS	X		X		N/A
71. Checkout S-IVB telemetry system	X		X		N/A
72. Calibration of S-IVB transducers	X		X		N/A
73. Conduct range safety test - S-IVB	X		X		N/A
74. Checkout S-IVB control system	X		X		N/A
75. Checkout S-IVB SSB	X		X		N/A
76. Checkout S-IVB propulsion	X		X		N/A
77. Checkout S-IVB EBW	X		X		N/A
78. Check S-IVB frequency response and actuator calibration	X		X		N/A
79. Calibrate S-IVB liquid level sensor	X				N/A

## APPENDIX A - VEHICLE PROCESSING OPERATIONS ITEM 1.9.1.1

PROCESSING FUNCTION	S-II with no restarts and S-IVB with 1 or 2 restarts (LOR and Sync Missions)	S-II with one restart; No S-IVB (LEO Mission)
	CHANGE	CHANGE
80. Conduct ullage checks on S-IVB	X	N/A
81. Conduct S-II engine ignition system checkout	X	X
82. Conduct S-II recirculation system electrical checkout	X	DELETE
83. Verify S-II switch selector operation	X	X
84. Conduct S-II umbilical disconnect leak check	X	X
85. Conduct S-II range safety checks	X	X
86. Conduct S-II telemetry checks	X	X
87. Checkout S-II temperature measurement	X	X
88. Checkout S-II engine actuation system	X	X
89. Checkout and leak check S-II propellant fill system	X	X
90. Checkout S-II separation system	X	X
91. Checkout S-II propellant dispersion	X	X
92. Conduct S-II/DDAS test	X	X
93. Checkout S-II engine safety circuits	X	X
94. Perform combined G&C tests	X	X
95. Conduct S-IVB preparations for malfunction OAT	X	N/A
96. Conduct S-II preparations for malfunction OAT	X	X
97. Add S-II APS checkout	X	NEW
<b>PHASE IV - VAB VEHICLE TESTS</b>		
98. Conduct L/V malfunction OAT	X	X
99. Conduct S-IVB differential pressure feedback test	X	N/A
100. Verify vehicle/propellant networks interface	X	X
101. Install S-IVB ordnance	X	N/A
102. Conduct S-IVB APS checkout	X	N/A
103. Install S-II ordnance	X	X
104. Checkout S-II S&A device	X	X
105. Conduct S-IVB live ordnance tests	X	N/A
106. Conduct S-II live ordnance tests	X	X
107. Checkout S-II measurements system	X	X
108. Conduct preparations for swing arm OAT	X	X

## APPENDIX A - VEHICLE PROCESSING OPERATIONS ITEM 1.9.1.1

PROCESSING FUNCTION	S-II with no restarts and S-IVB with 1 or 2 restarts (LOR and Sync Missions)	S-II with one restart; No S-IVB (LEO Mission)					
	CHANGE	NO CHANGE	CHANGE	NO CHANGE			
109 Conduct swing arm OAT			X			X	
110 Erect Spacecraft			X			X	
111 Conduct spacecraft testing			X			X	
112 Conduct preparations of spacecraft electrical mating			X			X	
113 Conduct preparations for S/V OAT #1			X			X	
114 Add S-II APS checkout			X			X	
PHASE VB - PAD/ SV INTEGRATION							
115 Conduct SV OAT #1	X		X			X	
116 Install S-IVB ordnance	X		X			N/A	
117 Install S-II ordnance	X		X			X	
118 Transfer to Pad	X		X			X	
119 Conduct pad ESE qualification	X		X			N/A	
120 Conduct LV/Pad electrical interface verification	X		X			X	
121 Conduct L/V hardwire tests	X		X			X	
122 Conduct S-IVB PC card calibration	X		X			N/A	
123 Conduct umbilical leak checks	X		X			X	
124 Prepare for S-II engine sequence test	X		X			X	
125 Prepare for S-IVB engine sequence test	X		X			N/A	
126 Conduct S-II engine sequence test	X		X			X	
127 Conduct S-IVB engine sequence test	X		X			X	
128 Conduct simulated cryogenic loading test	X		X			N/A	
129 Conduct facility power out test	X		X			X	
130 Conduct S-IVB PU calibration and checkout	X		X			X	
131 Conduct LV MCC-H interface command test	X		X			X	
132 Prepare for FRT	X		X			X	

## APPENDIX A - VEHICLE PROCESSING OPERATIONS ITEM 1.9.1.1

PROCESSING FUNCTION	S-II with one restart ; S-IVB with 1 or 2 restarts (LOR and Sync Missions)		S-II with one restart ; No S-IVB (LEO Mission)	CHANGE NO CHANGE
	CHANGE	NO CHANGE	CHANGE NO CHANGE	
PHASE VI - FINAL CHECKS, SERVICING & LAUNCH				
133 Conduct FRT	X			
134 Load S-IVB APS	X			
135 Add load S-II APS hypergolics				
136 Conduct CDDT preparations	X			
137 Conduct CDDT	X			
138 Securing L/V propellant systems		X		
139 Conduct countdown		X		
140 Launch		X		
141 Refurbishment			X	

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**APPENDIX B**  
**LAUNCH RULES**

## REDLINE COMPARISON

AS-503 MANDATORY	S-II		S-II - NO RESTARTS		S-II - ONE RESTART	
	SAME	DELETE	SAME	DELETE	SAME	DELETE
1. LOX Pump Discharge Temperature			X	X		X
2. Start Tank Gas Temperature			X	X		X
3. LH <sub>2</sub> Tank Precondition Temperature			X	X		X
4. Thrust Chamber Jacket Temperature			X	X		X
5. Engine Inlet LH <sub>2</sub> Temperature			X	X		X
6. Reservoir Outlet Fluid Temperature			X	X		X
7. He Tank Pressure			X	X		X
8. Start Tank Pressure			X	X		X
9. LOX Tank Ullage Pressure			X	X		X
10. LH <sub>2</sub> Tank Ullage Pressure			X	X		X
11. Valve Actuation He Bottle Pressure			X	X		X
12. Valve Actuation Regulator Outlet Pressure			X	X		X
13. Feedline Elbow Inlet Pressure			X	X		X
14. Common Bulkhead Internal Pressure			X	X		X
15. Engine Inlet LH <sub>2</sub> Pressure			X	X		X
16. Common Bulkhead Insulation Outlet Pressure			X	X		X
17. Sidewall Insulation Outlet Pressure			X	X		X
18. Hydraulic Gas Pressure			X	X		X
19. He Injection System Pressure			X	X		X
20. Common Bulkhead Internal Pressure			X	X		X
21. P. U. Valve Position			X	X		X
22. He Injection PRI Orifice Outlet Pressure			X	X		X
23. Hydraulic Reservoir Piston Position			X	X		X
24. Yaw Actuator Piston Position			X	X		X
25. Pitch Actuator Piston Position			X	X		X
26. Engine Cut-Off			X	X		X
27. LOX Depletion Sensors Open (Wet)			X	X		X
28. Fuel Depletion Sensors Open (Wet)			X	X		X
29. Main DC Bus Voltage			X	X		X
30. Main Battery Voltage			X	X		X
31. Instrumentation DC Bus Voltage			X	X		X
32. Instrumentation Battery Voltage			X	X		X
33. RSCR Signal Strength Low			X	X		X

REDLINE COMPARISON					
	AS-503 MANDATORY	S-II - NO RESTARTS		S-II - ONE RESTART	
		SAME	DELETE	SAME	DELETE
34.	Recirculation DC Bus Voltage			X	X
35.	Recirculation Battery Voltage			X	X
36.	Ignition Battery Voltage			X	X
37.	Ignition DC Bus Voltage			X	X
38.	115 VAC P. U. Package Voltage	X		X	
39.	LOX Fill/Drain Line Umbilical Coupling Pressure	X		X	
40.	Common Bulkhead Circuit H <sub>2</sub> Concentration	X		X	
41.	Common Bulkhead Circuit O <sub>2</sub> Concentration	X		X	
42.	LH <sub>2</sub> Feedline Circuit Hydrogen Concentration	X		X	
		Attitude Control Fuel Mod. Temp.			
		Attitude Control Oxidizer Mod Temp.			
		Attitude Control Tank Pressure			
		Oxidizer Tank Ullage Volume	Mod (APS) Pressure	Fuel Tank Ullage Volume	Mod (APS) Pressure
		TVC Battery Voltage	TVC Bus Voltage	Engine He Tank Press	LH <sub>2</sub> Pump Inlet Temp
		Engine LOX Pump Inlet Temp	Engine LOX Pump Inlet Temp	Engine LOX Pump Inlet	Fill & Drain Coupling Temp
		LH <sub>2</sub> Pump Inlet Temp	Fill & Drain Coupling Temp	LH <sub>2</sub> Pump Inlet	Fill & Drain Coupling Temp

## REDLINE COMPARISON

S-IVB MEASUREMENT (AS-503 MANDATORY)	S-IVB WITH J-2S REQUIRED	
	YES	NO
1. Fuel Pump Inlet Temperature		
2. GH <sub>2</sub> Start Bottle Temperature	X	X
3. Attitude Control Fuel Module Temperature	X	X
4. Attitude Control Oxidizer Module Temperature	X	X
5. Hydraulic Pump Inlet Oil Temperature	X	X
6. Reservoir Oil Temperature	X	X
7. Control He Regulator Discharge Pressure	X	X
8. Cold He Sphere Pressure		X
9. GH <sub>2</sub> Start Bottle Pressure	X	
10. Engine Control He Sphere Pressure	X	
11. Fuel Tank He Bottle Repressurization Pressure	X	
12. Attitude Control He Pressurization Tank Pressure	X	
13. Hydraulic System (Auxiliary Pump On) Pressure	X	
14. Reservoir Oil (Auxiliary Pump OFF) Pressure	X	
15. Oxidizer Tank Ullage Volume Mod. (APS) Press.	X	
16. Fuel Tank Ullage Volume Mod. (APS) Pressure	X	
17. LOX Tank Repressurization He Spheres Pressure	X	
18. Auxiliary Hydraulic Pump Air Tank Pressure	X	
19. Ambient He Pneumatic Sphere Pressure	X	
20. Fuel Tank Ullage Umbilical Pressure		X
21. Oxidizer Circulation Pump Flow Rate		X
22. Fuel Circulation Pump Flow Rate		X
23. Actuator Piston Pot Pitch Position	X	
24. Actuator Piston Pot Yaw Position	X	
25. Cut-Off Signal (Lock-In) Event	X	
26. Reservoir Oil Level	X	
27. Aft and Forward Battery Output Voltage	X	
28. Engine Control Bus Voltage	X	
29. RSCR Signal Strength Low Level	X	
30. Propellant Utilization Oven Stability Monitor	X	
31. Oxidizer Tank Umbilical Pressure	X	
32. PU System Ratio Valve (VSG 10-401)	X	
33. SPTS Case Temperature	X	

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**APPENDIX C**  
**INTERLOCK ANALYSIS**

**TABLE I**  
**INTERLOCKS DELETED FROM THE S-II SYSTEM**

RELAY	FUNCTION	REFERENCE FIGURE
K118	Recirculation Ready for Launch	2
K126	Any LH <sub>2</sub> Depletion C/O Sensors Dry	2
K227	LOX Return Line Valves Open	5
K223	All LOX Prevalves Open	5
K206	All LOX Prevalves Open	5
K228	Pump Valves Open	5
K217	Pump Valves Open	5
K226	All LH <sub>2</sub> Prevalves Closed	5
K213	All LH <sub>2</sub> Prevalves Closed	5
K218	Return Line Valve Open	5
K216	Close Recirculation Pump Return Line Valves	5
K215	Close Recirculation Pump Valves and Return Line Valves	5
A24K1	LOX and LH <sub>2</sub> Return Line and LH <sub>2</sub> Pump Valve Control	5
K111	Recirculation Stop Reset	6
K50	Recirculation Reset	6
K1-1	Ullage Trigger	6
K823	All Gas Generator Valves Closed	7
K125	Recirculation Ready for LOX Load	8
K237	10% LOX Level	8
K223	All LOX Prevalves Open	8
K206	All LOX Prevalves Open	8
K823	All Gas Generator Valves Closed	8
K9	Recirculation Bus Supervision	4
K96	+2DS11 Power On	10
K40	Recirculation Power Transfer Isolation	10
K28	Recirculation Bus Power Transfer	10
K34	Recirculation Bus Internal	10
K103	OAT Recirculation Bus Supervision	10
K18	Recirculation Bus Voltage OK	4
K848	LH <sub>2</sub> 1 Dry	9
K850	LH <sub>2</sub> 2 Dry	9
K852	LH <sub>2</sub> 3 Dry	9
K854	LH <sub>2</sub> 4 Dry	9
K856	LH <sub>2</sub> 5 Dry	9

**NOTE** The prevalve interlocks deleted from the Recirculation System should be used in the Propellant Loading Chain to ensure that the prevalves are open prior to start of propellant flow.

**TABLE II**  
**INTERLOCKS DELETED FROM S-IVB SYSTEM**

RELAY	FUNCTION	REFERENCE FIGURE
K54	Ullage Rocket Pilot Relays Reset	2, 11
K633	LH <sub>2</sub> Chilldown Inverter Power On	2, 11
A45A6K6	LH <sub>2</sub> Chilldown Inverter Power On	13
K623	LH <sub>2</sub> Chilldown Valve Open	2, 11
K631	LH <sub>2</sub> Prevalve Closed	2, 11
K622	LOX Chilldown Valve Open	2, 11
K632	LOX Chilldown Inverter Power On	2, 11
A45A6K5	LOX Chilldown Inverter Power On	13
K629	LOX Prevalve Closed	2, 11
K646	LOX & LH <sub>2</sub> Prevalve Emergency Close Command	2, 11
K639	LOX & LH <sub>2</sub> Prevalve Emergency Close Command	13
K424	LH <sub>2</sub> Bleed Valve Closed	2, 11
A45A9K19	Fuel Bleed Valve Closed	13
K425	LOX Bleed Valve Closed	2, 11
A45A9K18	LOX Bleed Valve Closed	13
K890	70 lb. Thrust Ullage Engine Relay Reset	12
A3A10K1	Ullage Rocket Relays	12
A3A10K2	Ullage Rocket Relays	12
A3A10K3	Ullage Rocket Relays	12
A3A10K4	Ullage Rocket Relays	12

**NOTE** These interlocks can be deleted from the interlock chain which activates K968 - S-IVB Stage Ready for Firing and K972 - S-IVB Stage Ready for Launch.

**TABLE III**  
**INTERLOCKS ADDED TO S-II SYSTEM FOR LEO MISSION**

<u>Interlock Condition</u>	<u>Reason</u>
APS No. 1 Engine Valve Power On	To ensure that APS engine valve power is available prior to S-IC ignition.
APS No. 2 Engine Valve Power On	Same as above
LH <sub>2</sub> Vent Directional Control in Flight Position	To ensure that the LH <sub>2</sub> tank is venting through balanced vent system.
Auxiliary Hydraulic Pump Power On (Flight Mode)	To ensure that power is available for TVC during idle mode.

## SYMBOLS

— [K944] — indicates normally open contacts of K944

— [K944\*] — indicates normally closed contacts of K944

— [K944] — indicates normally open contacts of K944 with energizing coil represented by arrow

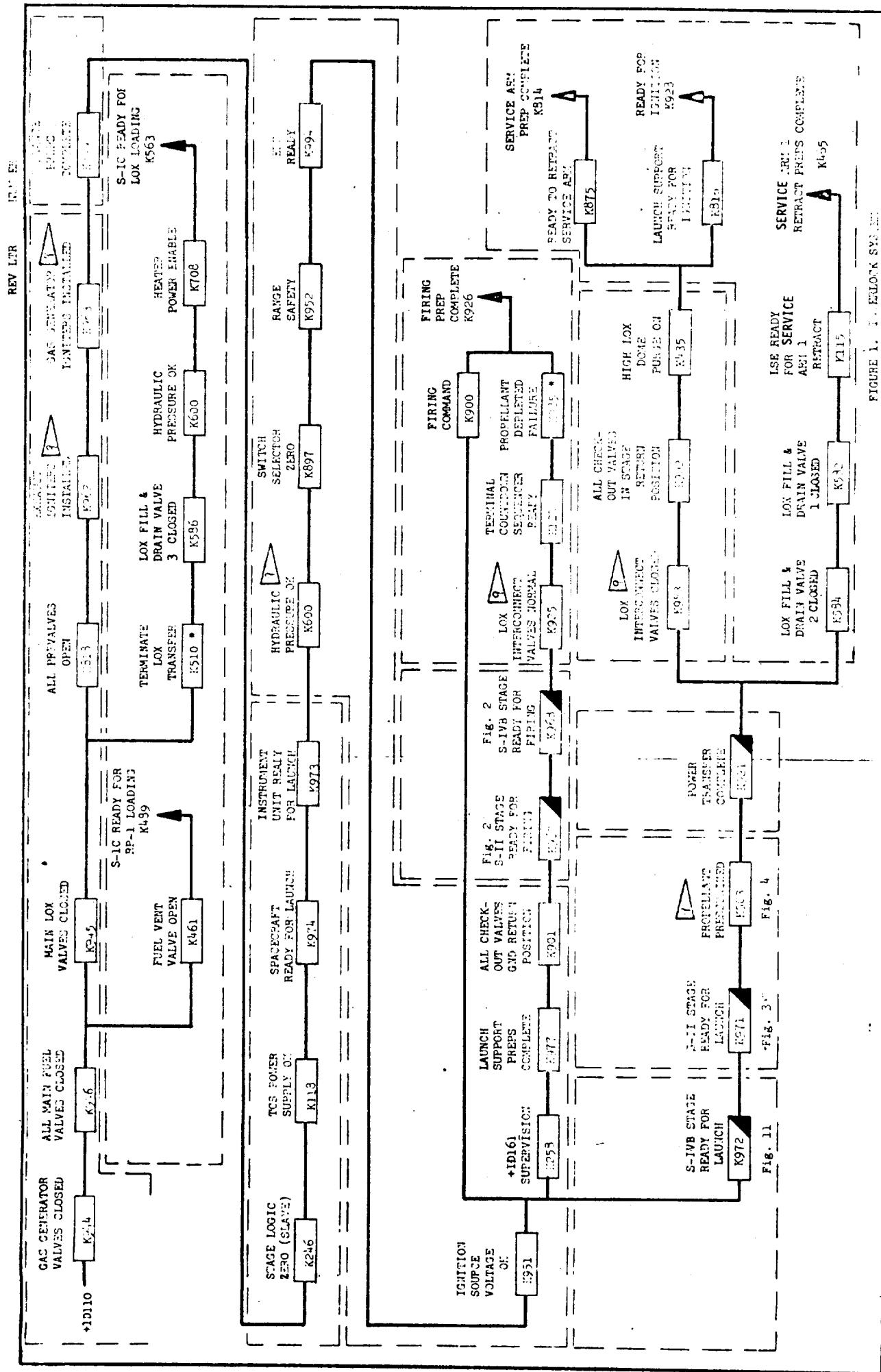
— [K101] — indicates open contacts of magnetic latch - unlatch relays, with the U coil (represented by U) last energized

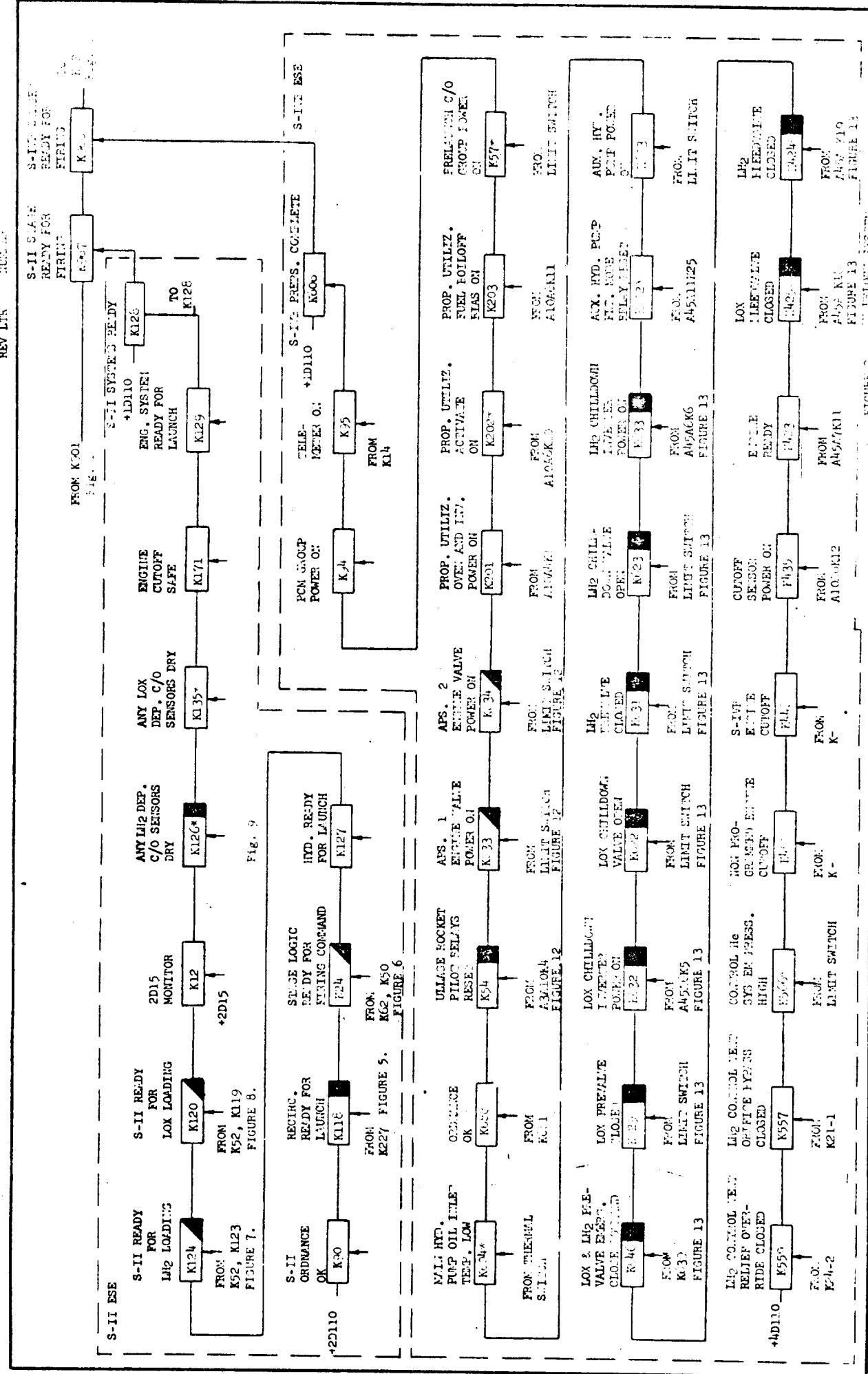
 Interlock Deleted

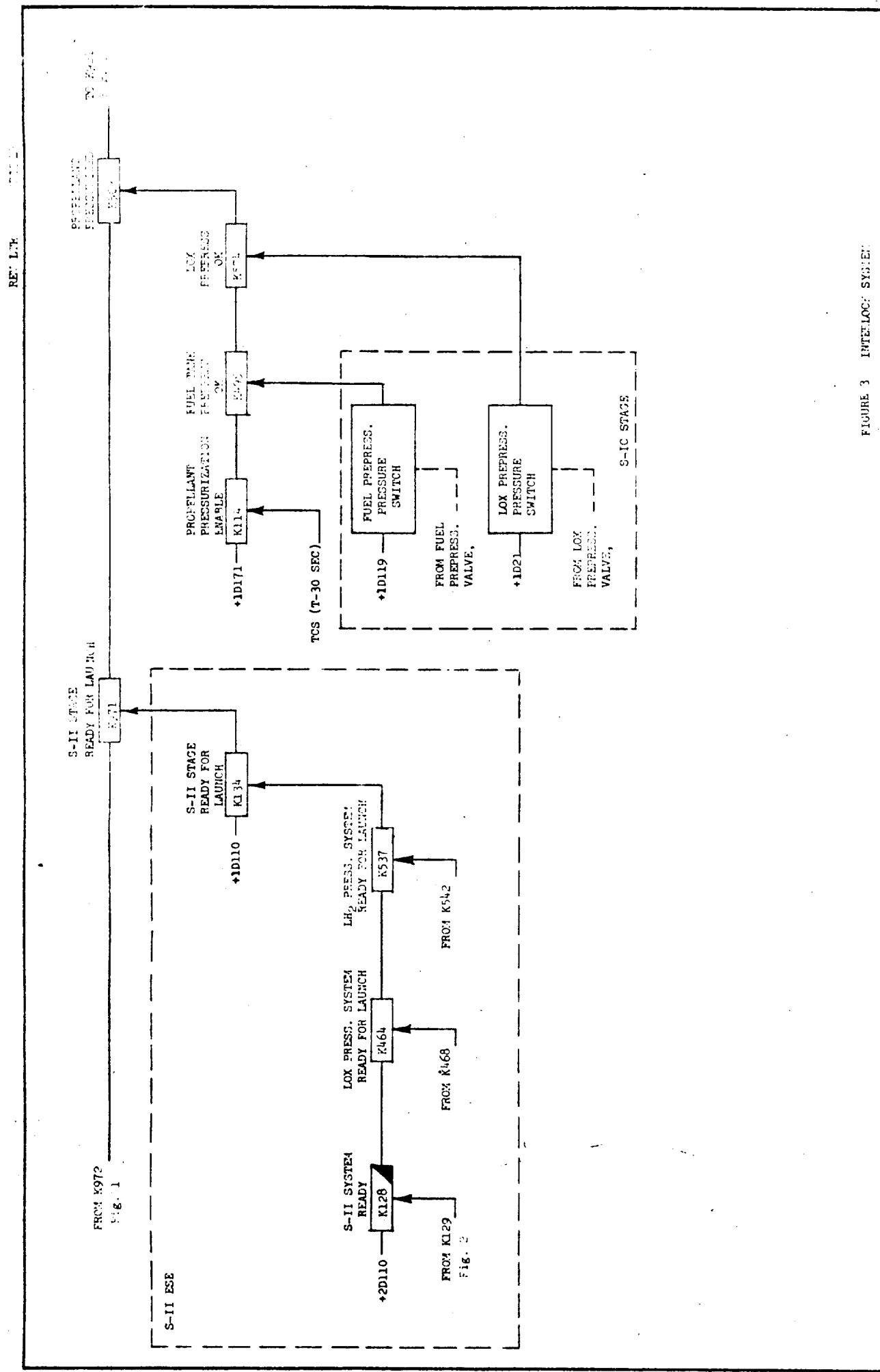
 Interlock Modified by Deleted Function Upstream

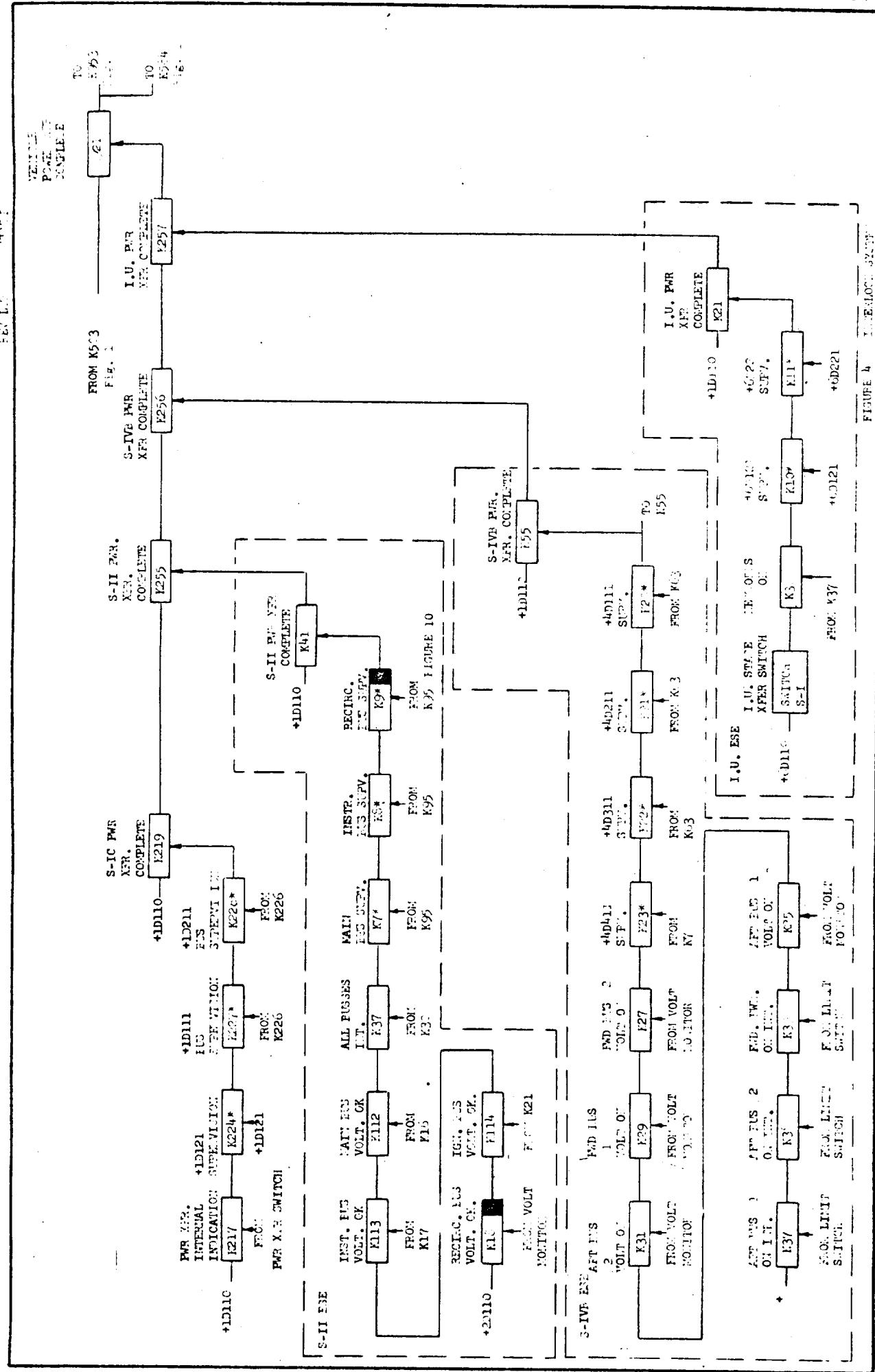
## NOTES

1. The interlock diagrams shown in Figures 1 through 13 are part of D5-16266-4 "Functional Analysis Document for Saturn V Interlock System" and should be referred to for information not affected by J-2S
2. Continuity must be provided in an interlock chain for those relays which are deleted as a result of J-2S.

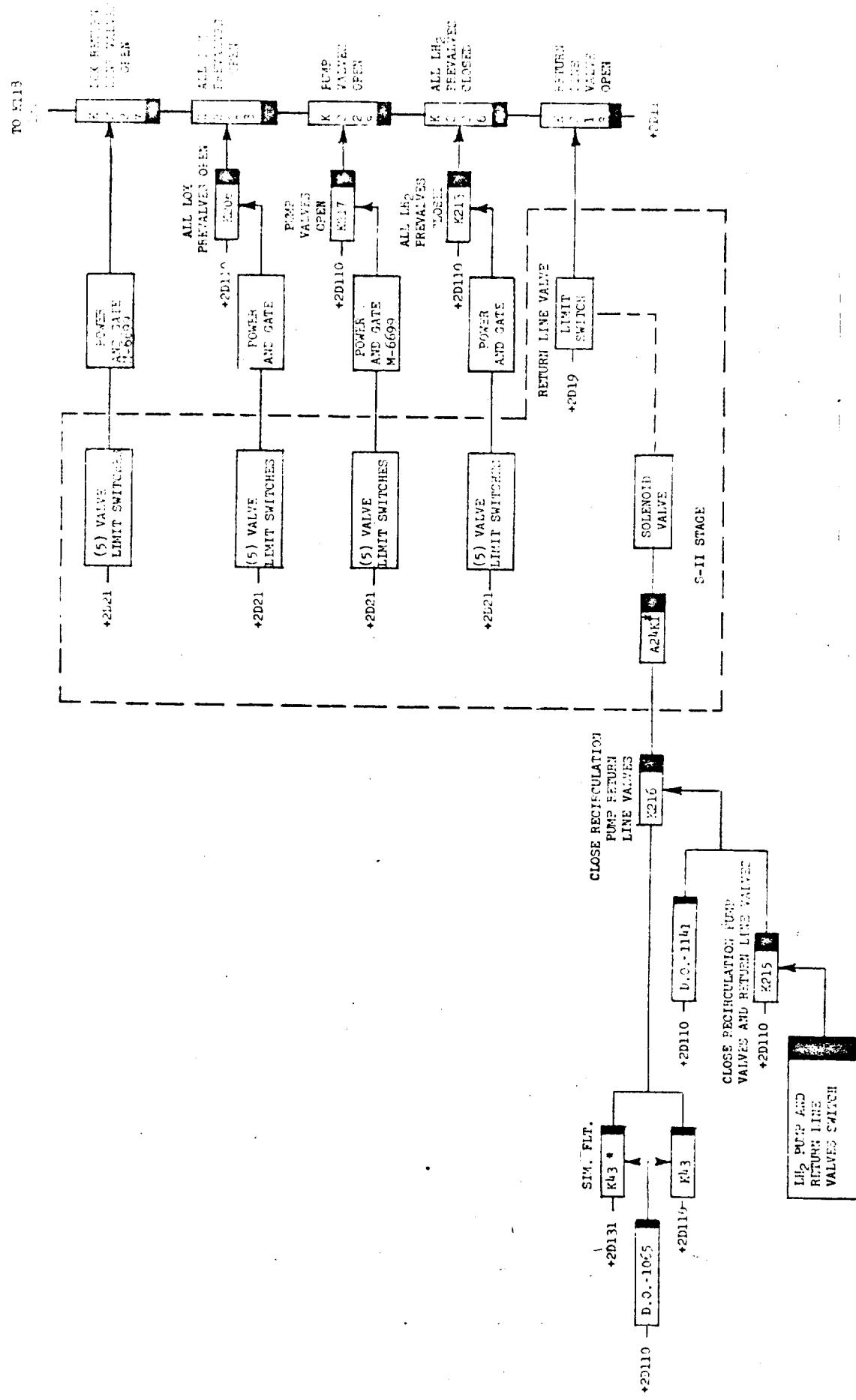


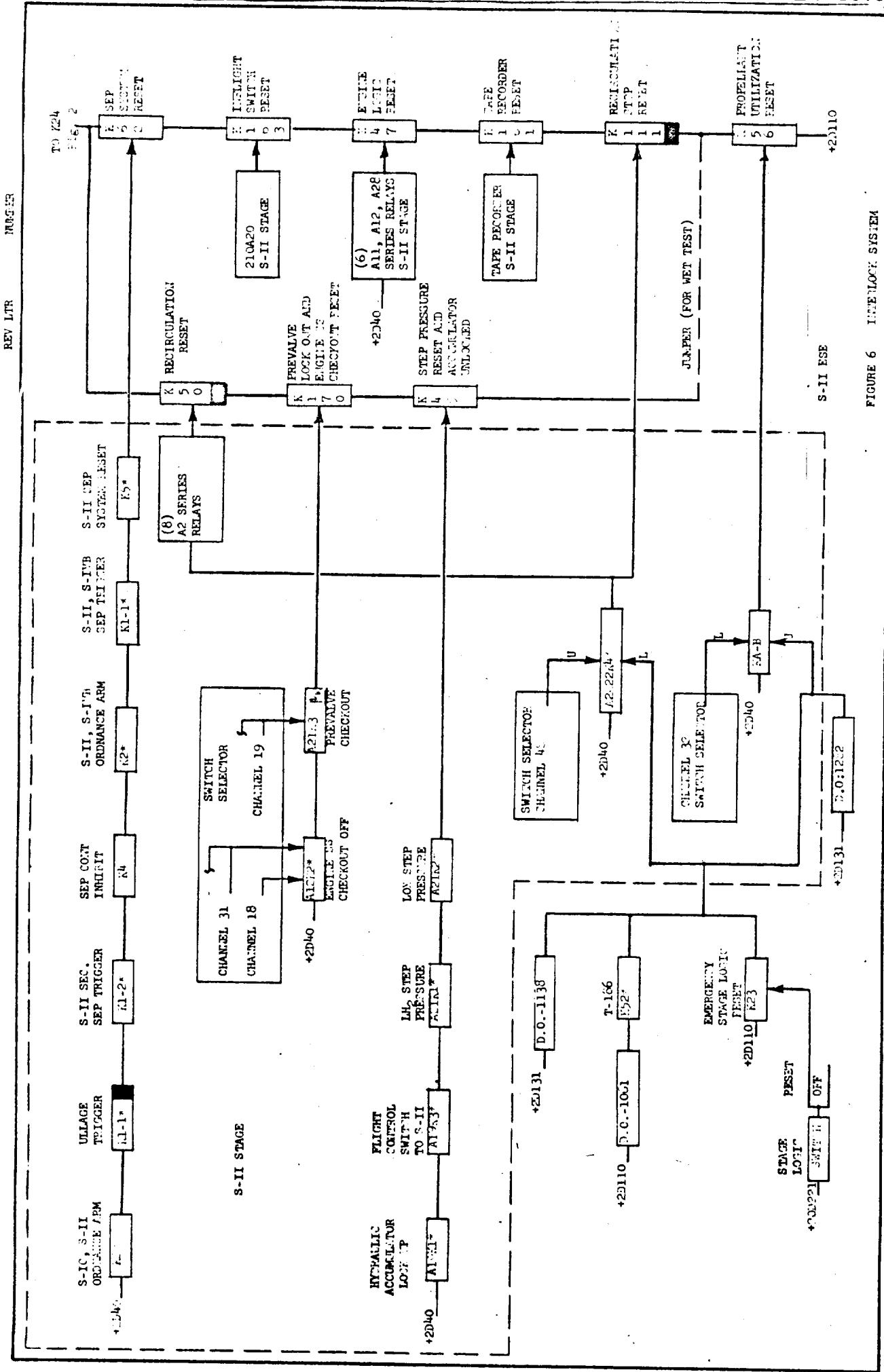




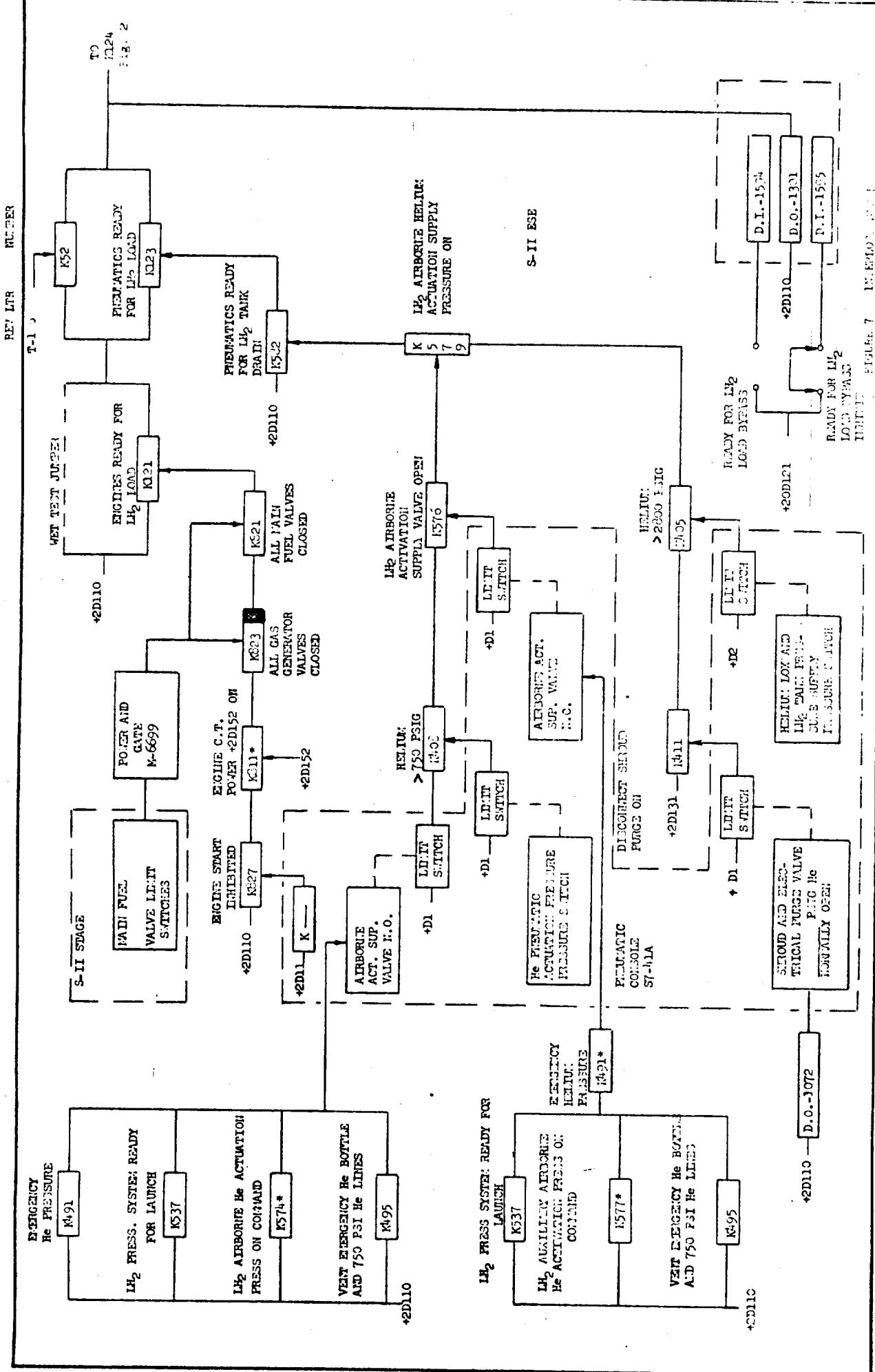


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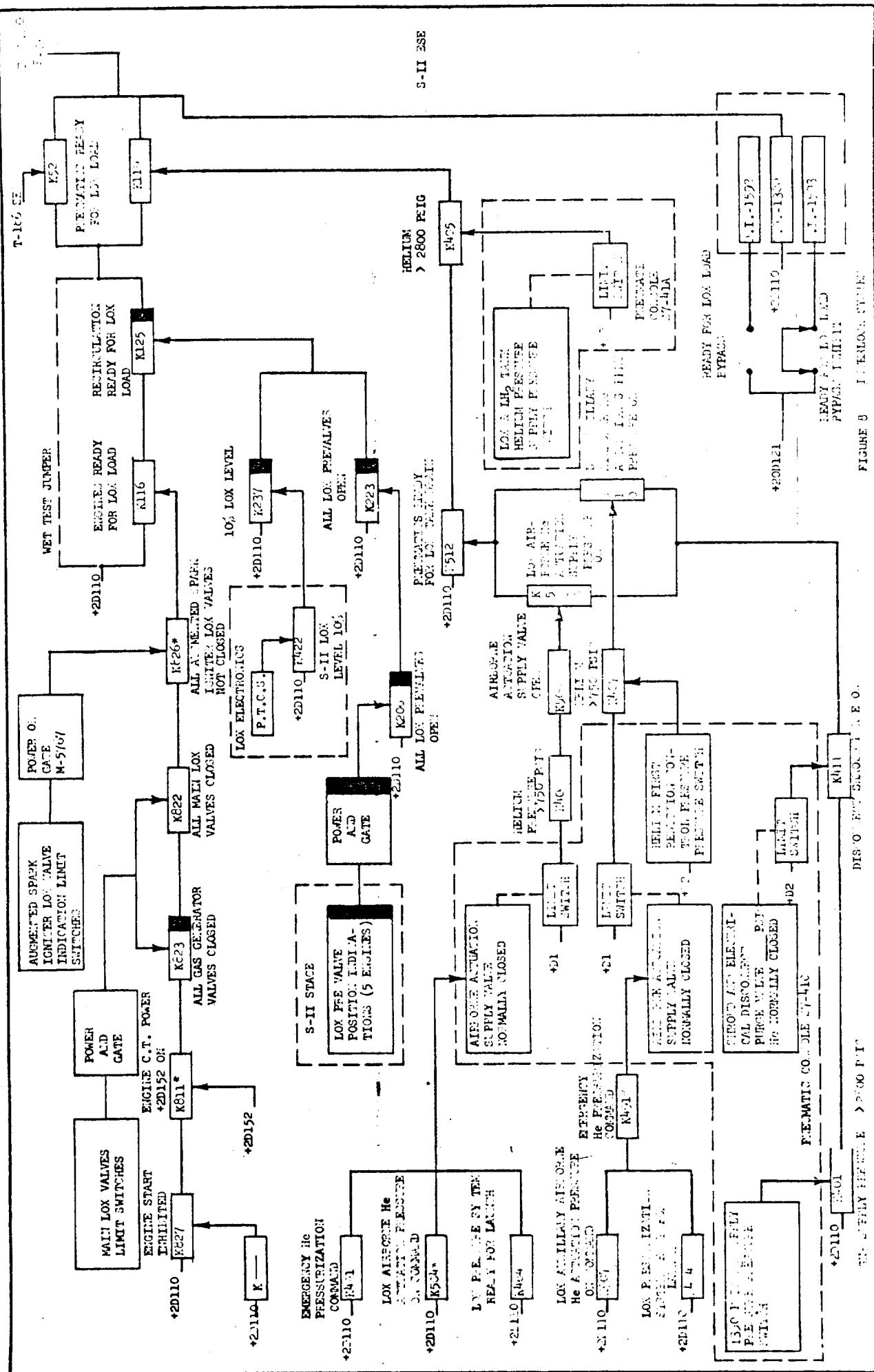


Sheet C-11



REV LTR

NOTE:



REV LTR DMEP

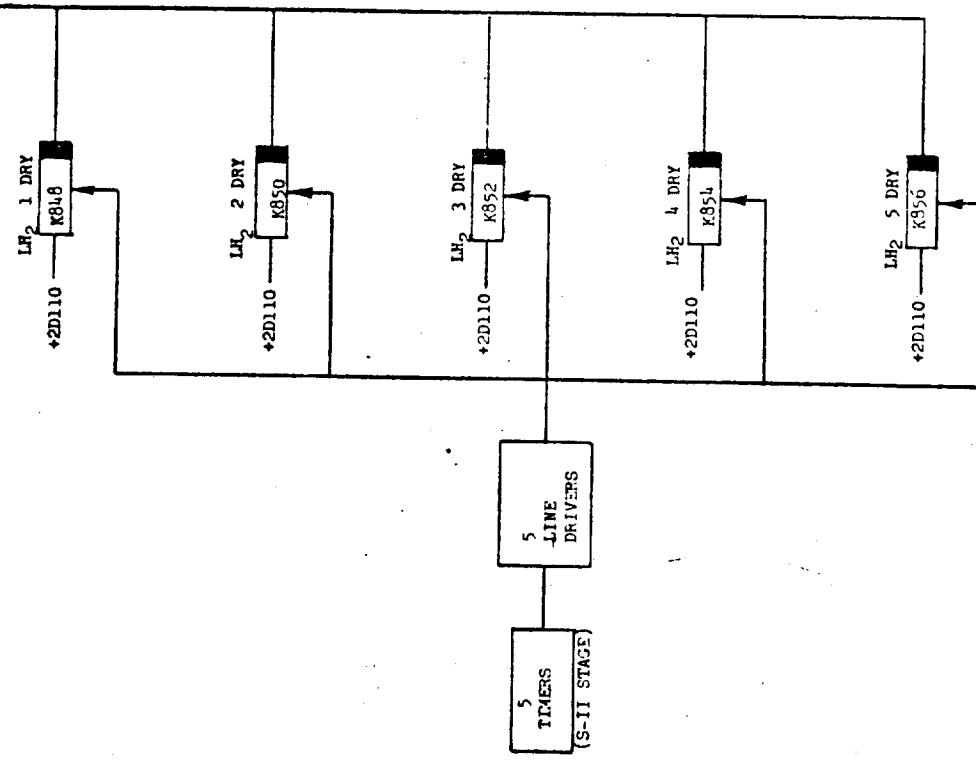
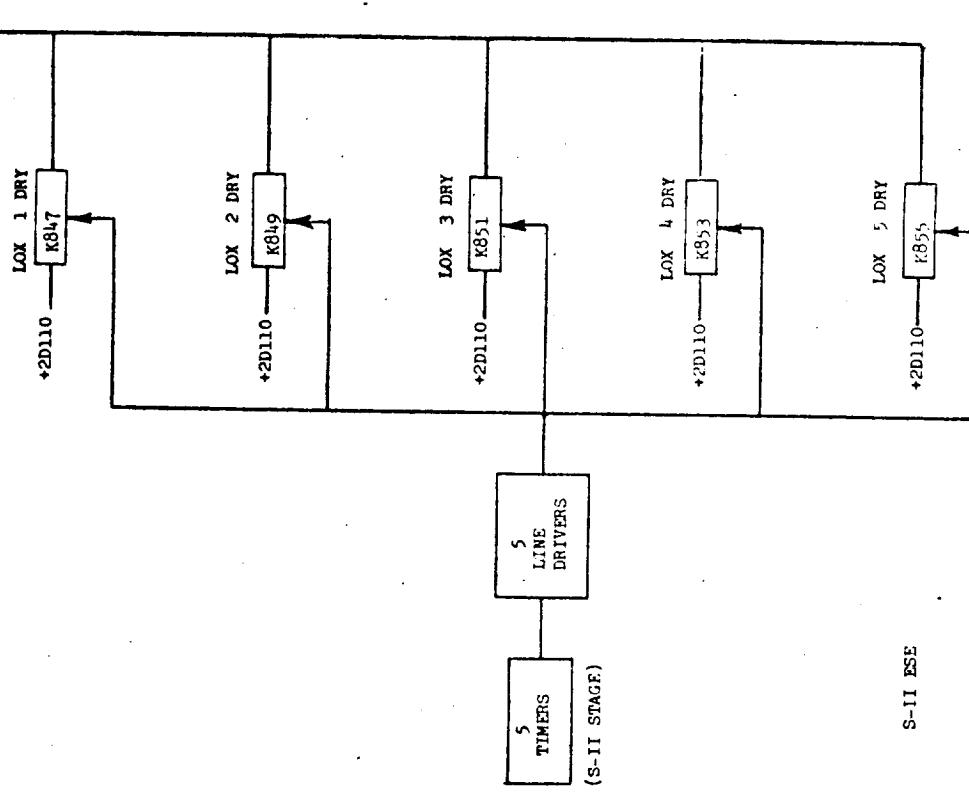
TO K126  
Figure 2TO K135  
Figure 2

FIGURE 9 INTERLOGIC SYSTEM

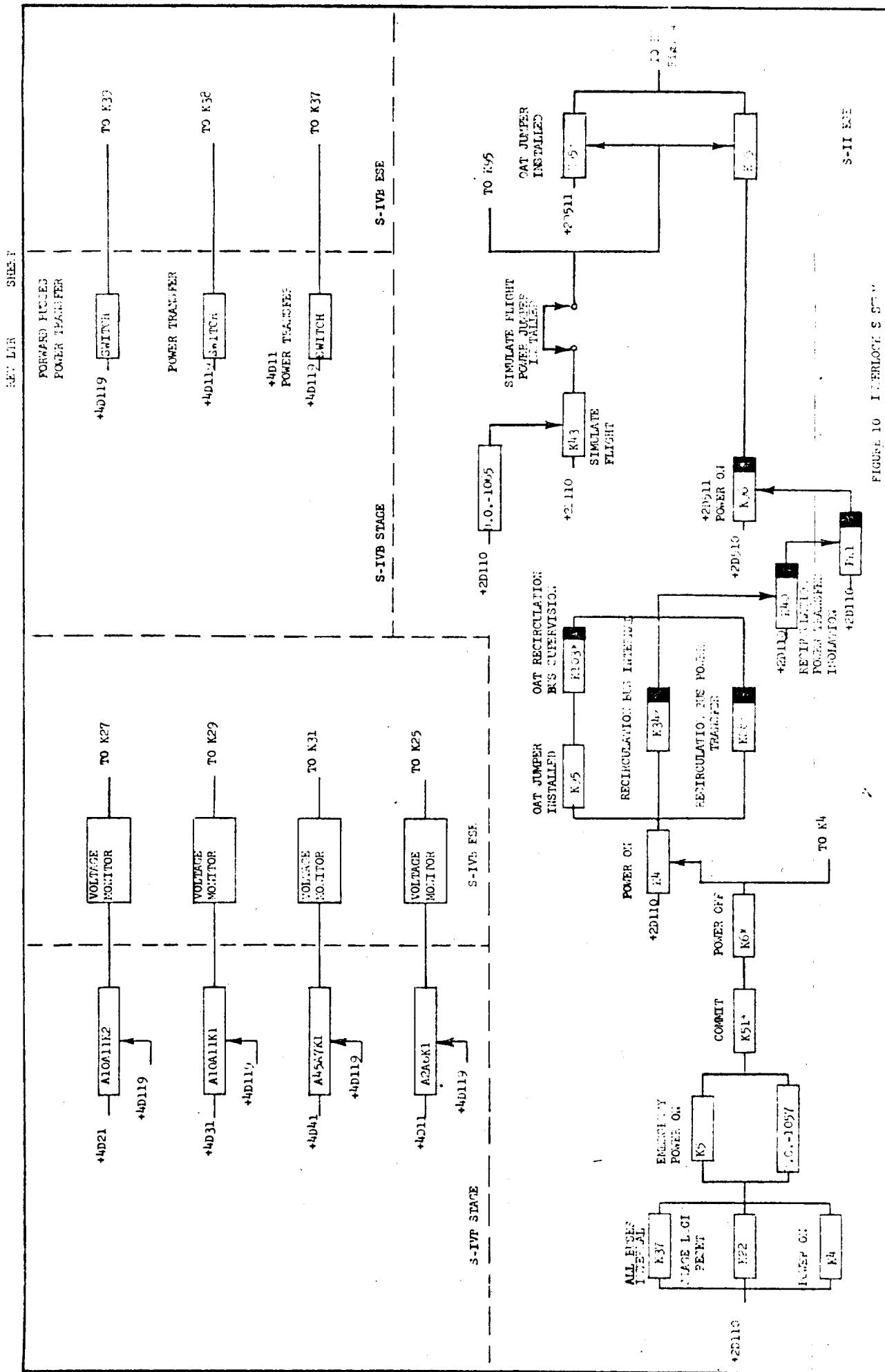
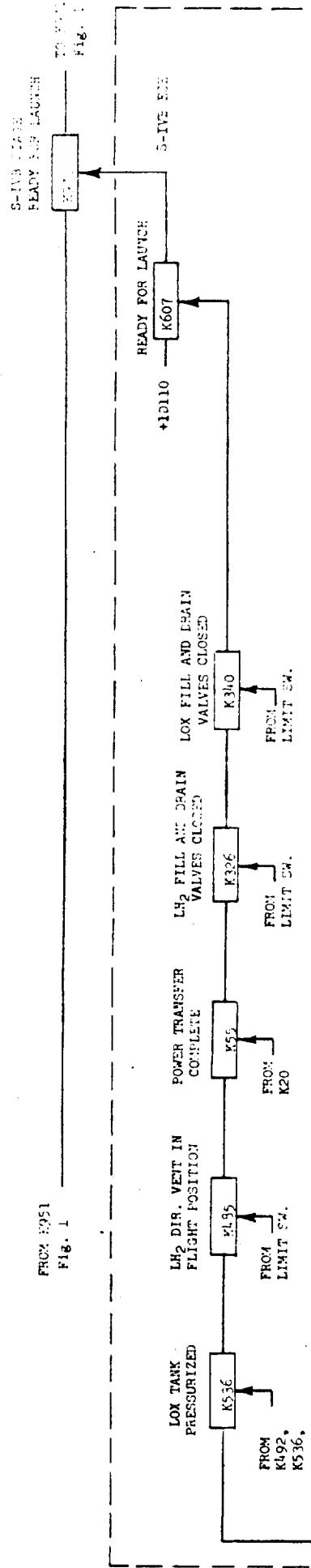


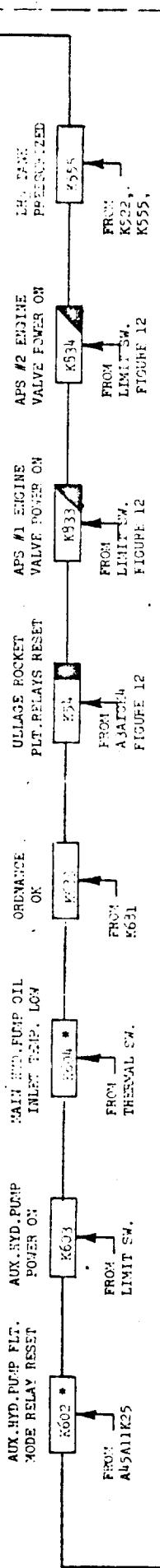
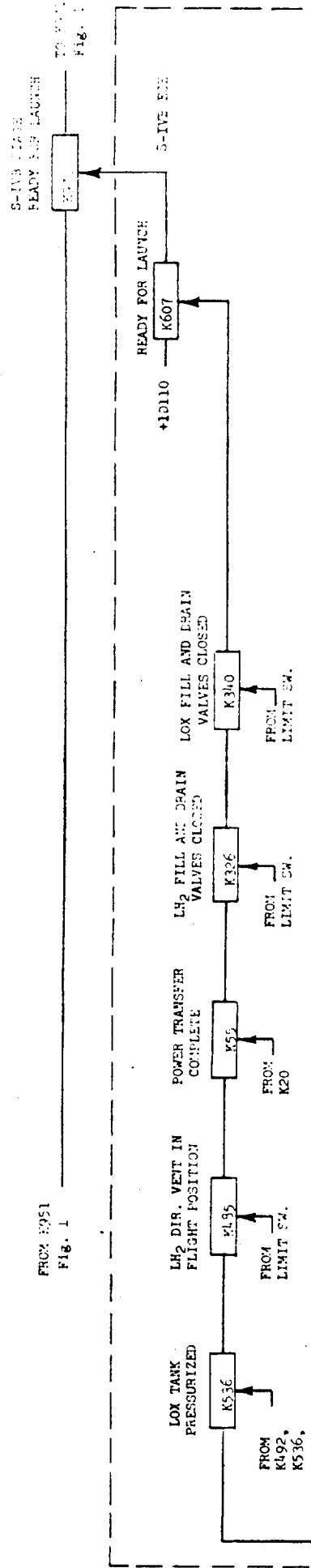
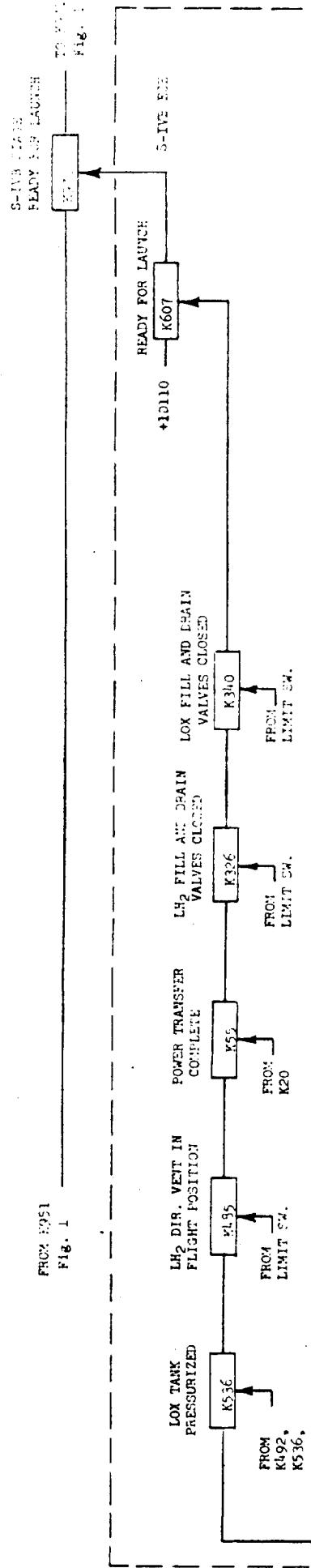
FIGURE 10 INTERLOCK SYSTEM

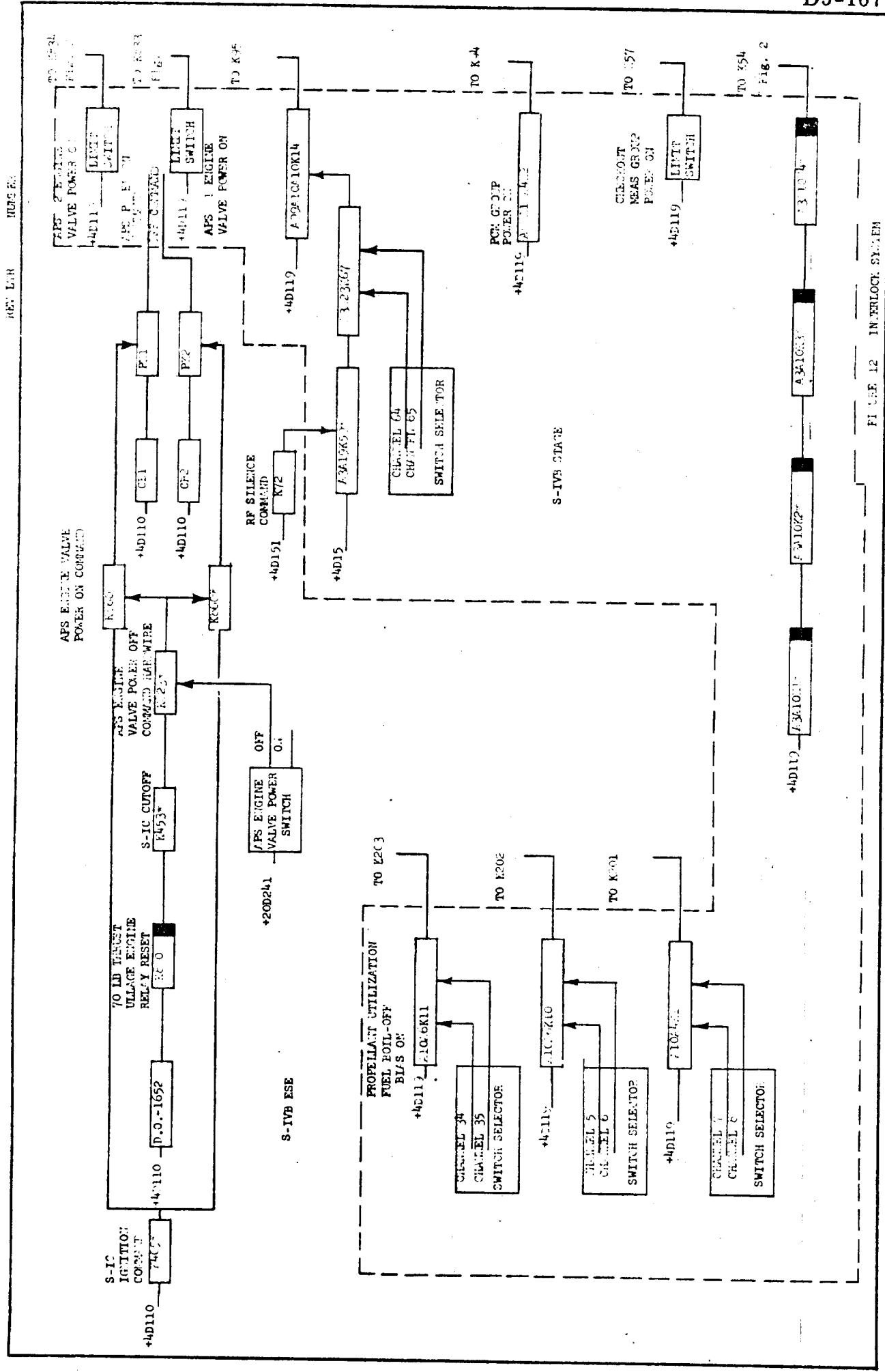
FROM K951  
FIG. 1

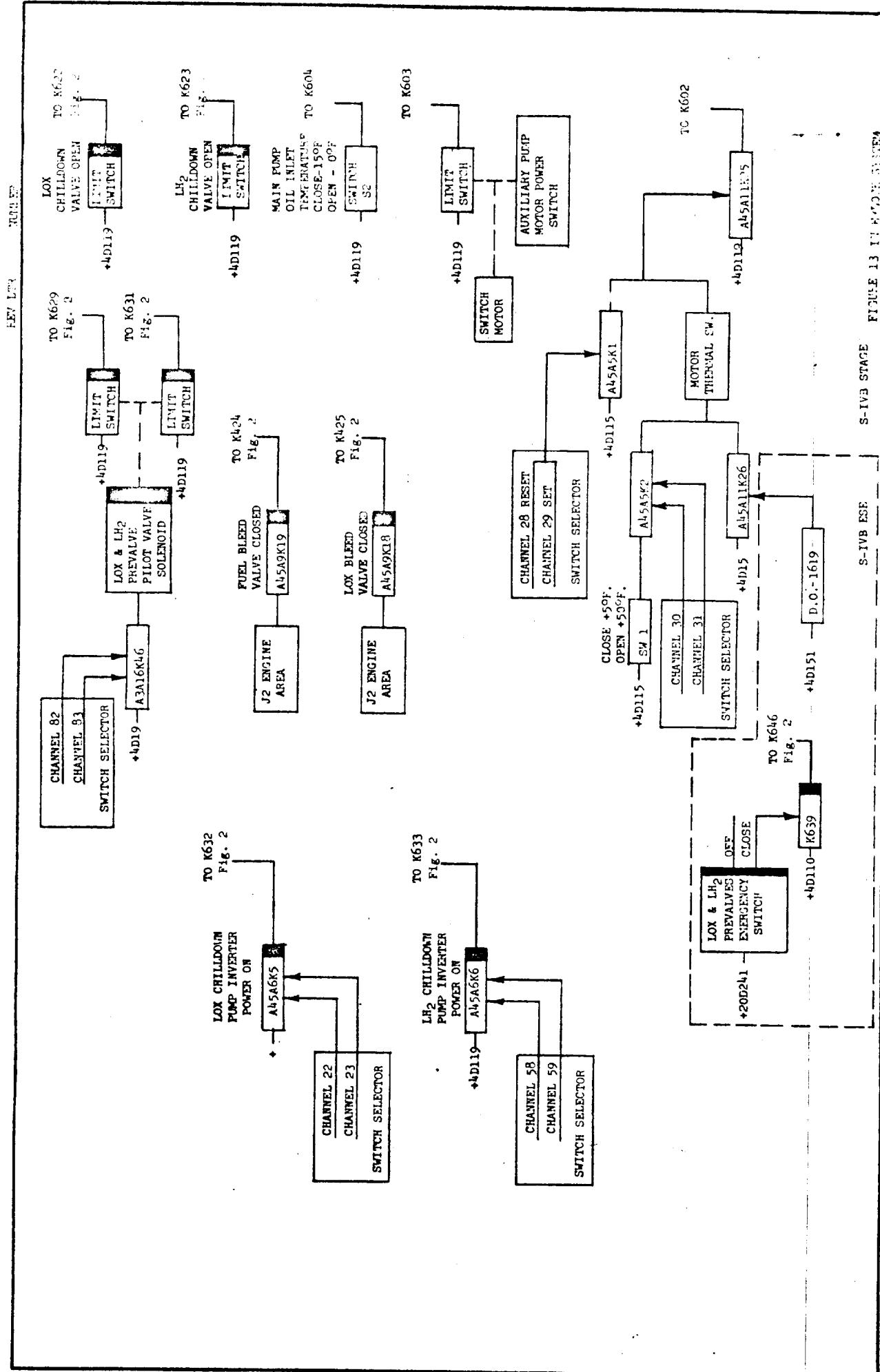


PER. 1

FIG. 1







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**APPENDIX D**  
**REQUIREMENT CHANGE SHEETS**

REQUIREMENTS CHANGE SHEET 1		S-II APS	S-II APS	
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
1.0 Provide KSC capability to install, checkout, monitor and service an auxiliary propulsion system similar to the S-IVB APS on the S-II stage.	All		The addition of one restart capability on the S-II stage results in the vehicle requirement for attitude control. This vehicle requirement will be satisfied by the addition of an S-IVB type APS system (without the APS ullage). This will result in modification to the GSE ESE as described in detail requirements below.	x x
<u>S-II-ONE RESTART</u>				
1.1 Provide platform access to the vehicle at vehicle station 1541.00 for APS servicing.	MSS	New procedure must be prepared for S-II.	MSS Platform 1 will be relocated to provide access for APS servicing	x x
1.2 Provide capability to service S-II APS with oxidizer N <sub>2</sub> O <sub>4</sub> . <sup>1</sup>	MSS	New procedure similar to S-V 24109 must be prepared for S-II APS servicing.	Provide APS oxidizer control assembly on Platform #1 and a valve isolation box-oxidizer at 133-ft. level on MSS & associated valving, plumbing & equipment	x x
1.3 Provide capability to service the S-II APS with fuel Monomethyl Hydrazine. <sup>2</sup>	MSS	Same as 1.2	Provide APS fuel control assembly on Platform #1 and APS valve isolation box - fuel at 133-foot level on MSS & associated valving, plumbing, & equipment	x x
1.4 Verify panel lamps to confirm new panel indicators.	LCC	Procedure similar to V-21370 - S-IVB will be required.	Add verification that panel lamps work.	x
<u>1</u> Exact quantity of propellant dependent on S-II vehicle requirements.				
<u>2</u> An alternate servicing method (carry-on) will also be considered during the study.				

REQUIREMENTS CHANGE SHEET		1		S-II APS	
REQUIREMENTS CHANGE		Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
S-II-ONE RESTART - (Cont'd.)		LCC		An APS launch and monitor panel will be required in the S-II section of the LCC. [See electrical section requirements sheet.]	x
1.5 Provide panel indicators to monitor all APS functions (measurements).					x
1.6 Provide APS Laboratory checkout capability	Low Bay		N.A.procedure similar to IV-21241 required. Also V-24092	Laboratory test equipment currently used for C/O of S-IVB APS will be required.	x
1.7 Ensure S-II APS Electrical Interface compatibility	Low Bay		N.A.procedure similar to V-21083 required.	Prepare new procedure	x
1.8 Verify APS to vehicle interface	High Bay		N.A.procedure similar to V-21313 will be required.	Prepare new procedure.	x
1.9 Functionally test APS current signature recording system.	Low Bay		N.A.procedure similar to V-23137 required.	Prepare new procedure.	x
1.10 Provide capability for APS module subsystem checkout - stage mounted.	High Bay		V-24266 (Douglas)	Prepare new procedure	x

REQUIREMENTS CHANGE SHEET 1		S-II APS			
REQUIREMENTS CHANGE		Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
				Change Hardware	
1.11	Provide OIS capability for monitor & control of Hypergol Loading	MSS			
1.12	Provide OTV capability for monitor of Hypergol Loading	MSS	New procedure required	Install 4 OIS boxes on MSS Platform No. 1	x
1.13	Modify MSS to provide access to APS plumbing and bulkheads	MSS		OTV cameras located on the MSS for monitoring of S-IVB APS loading will be relocated to the 133-ft. level for the LEO Mission (S-II with one restart) since they will not be required at S-IVB level	x
1.14	Provide normal safety equipment and precautions for Hypergol Loading	MSS		Pipe chases and catwalks from valve boxes to APS bulkhead at the 133-ft. level of the MSS (both sides)	x
1.15	Provide MSS GN <sub>2</sub> for isolation valve box (oxidizer & fuel) purge and APS control assembly purge 15 psig & 3000 psig	MSS		Provide safety showers, eyewashes and first aid stations at 133-ft. level of MSS	x
				Provide tap-off capability from GN <sub>2</sub> lines on MSS at 133-ft. level to S-V-24109 must be provided	x
				S-II NO RESTART	
1.16	No change to KSC equipment or procedures			The S-II stage with no restart will not require an APS	

REQUIREMENTS CHANGE SHEET 2		S-IVB APS		GSE/ESE IMPACT	X	X
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	Hardware Change			
2.0 Modify KSC capability to install, checkout, monitor and service the S-IVB Auxiliary Propulsion System due to the deletion of the APS ullaging rockets.	All			The idle mode capability of the J2S eliminates the need for APS ULLAGING. This vehicle change will be satisfied primarily by deletion of APS ullaging checkout and servicing functions at KSC. The detailed modifications required are described in the detailed requirements listed below.	X	X
2.1 Verify panel lamps are operating.	LCC	V-21370		Delete indication 70 lbs. from APS launch and monitor panel	X	X
2.2 Modify APS lab checkout.	Low Bay	V-24092		Delete ullage thrust engine leak and functional check, and ullage thrust engine valve current and voltage signatures.	X	X
2.3 Modify APS lab checkout to delete checks of the test circuits for the APS ullage engine control, and to delete leak and functional tests of the ullage thrust engine.	Low Bay	I-21241 V-24092		Delete checks of test set circuits for APS ullage control.	X	X
				Procedure change only. Procedure change only.	X	X

See electrical Requirements Sheet for details.

REQUIREMENTS CHANGE SHEET 2		S-IVB APS	
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT
2.4 Modify interface compatibility tests to omit the impedance measurement test on the APS ullage engine valve circuits.	Low Bay	V-21083 V-21313	Procedure change only. Procedure change only.
2.5 Modify test of APS circuits to delete ullage engine valve current and voltage measurements.	Low Bay	V-23137	Procedure change only.
2.6 Modify the APS subsystem checkout - stage mounted test to delete functional check of the ullage thrust engine valves.	High Bay	V-24266	Procedure change only.

REQUIREMENTS CHANGE SHEET		3 RECIRCULATION CHILDDOWN SYSTEM			
REQUIREMENTS CHANGE		Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
Hardware Change	Procedure Change			Hardware Change	Procedure Change
3.0 Modify KSC capability for servicing and c/o due to deletion of the LOX and LH <sub>2</sub> Chilldown System	All			The vehicle requirement for propellant conditioning is deleted due to idle mode capability of the J-2S vehicle. This vehicle change results in elimination of the LOX and LH <sub>2</sub> Chilldown Systems. Valves, pumps and prevalves actuation control module and associated wiring and plumbing will be deleted from the S-II stage. The S-IVB stage will eliminate the recirculation system but not the prevalves. This will result in modification of purging, chilldown sequencing and c/o operations at KSC. The detailed requirements are listed below.	X
<u>S-IVB - ONE OR TWO RESTARTS</u>		Low Bay	V-21268	Modify procedure and delete applicable indicators.	X
3.1 Modify requirements for vehicle interface compatibility test to delete requirements for measuring resistance of chilldown pumps and capacitance of LOX depletion sensors.				(3)	
3.2 Modify requirements for the ESE hardline control verification test to delete control of prevalves and Chilldown System.				(3)	
3.3 Delete the leak and functional check of the LOX and LH <sub>2</sub> Recirculation Systems		Low Bay	V-24090	Modify procedure	X
				See electrical section	(3)

REQUIREMENTS CHANGE SHEET 3		RECIRCULATION CHILDDOWN SYSTEM		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	Procedure Change Hardware Change
S-IVB - ONE OR TWO RESTARTS	Pad	S-V-24107	Modification of procedure.	X
3.4 Modify Propulsion System pre-flight preps to eliminate need for visual inspection of the LOX and LH <sub>2</sub> Recirculation Systems.	Low Bay	V-26002	Modify procedure.	X
3.5 Delete the leak and functional check of the Thrust Chamber Chilldown System.	Low Bay	S-V-26003	Modify procedure.	X
3.6 Modify umbilical line blowdown to eliminate thrust chamber chilldown functions.	High Bay	V-20010	Modify procedure.	X
3.7 Delete simulated recirculation and chilldown functions from OAT #1.	Pad	V-20011	Modify procedure.	X
3.8 Delete simulated recirculation and chilldown functions from FRT.	Pad	V-20060	Modify procedure.	X
3.9 Delete all recirculation and chilldown functions from CDDT.	Low Bay	IV-21267	Delete procedures.	X
3.10 Delete tests for chilldown load simulator verification and Chilldown Inverter System.		IV-2126		

REQUIREMENTS CHANGE SHEET		RECIRCULATION CHILLDOWN SYSTEM		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE / ESE IMPACT	
<u>3.11 - NONE OR ONE ITEM</u>				
3.11 Modify the S-II propellant functional and leak checks and the Engine System leak and functional tests to delete functions associated with recirculation and chilldown.	Low Bay	V-25250	Procedure change only.	X
3.12 Delete all functions associated with checkout and servicing of the helium injection supply bottle.	All		Modify Helium Supply System to delete need for servicing helium injection bottle.	X
3.13 Deactivate thrust chamber chill circuit from A7-71 LH <sub>2</sub> heat exchanger.	Pad		Prelaunch conditioning of engine thrust chamber is no longer required. See Requirement 7.12 for GSE changes.	X
3.14 Eliminate checkout of Engine Fuel Recirculation System supply	Pad			X

REQUIREMENTS CHANGE SHEET 4		ULLAGE ROCKET SYSTEM		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
S-IVB ONE OR TWO RESTARTS	All		The vehicle requirement for ullage rockets has been deleted due to the idle mode capability of the J-2S stages and zero MPSH requirement for start. KSC modifications will be required to delete all ullage rocket functions from procedures and to delete equipment required to install, C/O and monitor these rockets. Detailed changes to the KSC requirements are discussed below.	X X
4.0 Modify KSC capability for C/O installation, servicing and monitor of ullage rocket systems due to deletion of S-IVB Ullage Rocket System.			These vehicle changes will result in the deletion of the procedures for receiving, assembly installation and jettison fuse installation and checkout. A corresponding deletion of KSC handling and checkout for this system will be realized.	X
4.1 Delete the 2 solid propellant ullage rockets and their fairings, the rocket ignition system and the rocket jettison system	Low Bay	O-IV-29113 0-V-29016 0-V-39003 0-V-21056 0-V-39000 0-V-39002	V-21086	Procedure change only
4.2 Modify the EBW subsystem test to delete test of ullage rocket ignition and jettison EBW's	Low Bay	Pad	V-30539	Procedure change only
4.3 Modify the procedure for S-IVB preps for CDDT and countdown to eliminate ullage rocket ignition and jettison arming				

REQUIREMENTS CHANGE SHEET 4		ULLAGE ROCKET SYSTEM (CONTINUED)		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
S-II - NONE OR ONE RESTART				
4.4 Delete the four solid ullage rockets, the two EBW firing units and detonators, the CDF manifolds, assemblies and initiators	High Bay	O-V-29022 and, NAA Drawings V7-540350 V7-430004 V7-317037	These vehicle changes will result in the deletion of all procedures for receiving assembly, installation and removal of the ullage rockets and deletion of ignition fuse installation and checkout procedures. A corresponding deletion of KSC handling and checkout equipment for this system will be realized.	X
4.5 Modify ordnance installation procedures to delete all activities related to the ullage rocket system	VAB High Bay	O-V-20032	Procedures change only	X

REQUIREMENTS CHANGE SHEET		5 ELECTRIC POWER	
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT
CONFIGURATION:			X
ONE RESTART			
5.1 Delete existing AFT #1 battery and replace with smaller battery.			
5.2 Receive new battery at KSC		No change	
5.3 Service new battery.		No change	
5.4 Install new battery	Pad	No change	
5.5 Delete childdown inverters		Delete: IV-21226	X

REQUIREMENTS CHANGE SHEET		5 ELECTRIC POWER		Hardware Change	
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	Procedure Change	Hardware Change
CONFIGURATION: S-IVB/J-2S WITH TWO RESTARTS				X	
5.6 Delete existing FWD #1 battery and replace with 2 larger batteries.					X
5.7 Receive new batteries at KSC.		No change.		X	
5.8 - Receive E/I switch at KSC.					X
5.9 Service new batteries.				X	
5.10 Checkout E/I switch.			No change - switch operates on existing internal/external power switchover.	X	
5.11 Install new batteries.	Pad				X
5.12 Delete chilldown inverters			Delete: IV-21226		X

REQUIREMENTS CHANGE SHEET 5 ELECTRIC POWER		PROCEDURES AFFECTED	GSE/ESE IMPACT	
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
<u>CONFIGURATION: S-II/J-2S WITH NO RESTARTS</u>				
5.13 Delete recirculation and ignition batteries, bus and wiring provisions.	Pad	V-21111		X
5.14 Delete external recirculation power supply.	Pad		Delete 2D500 power supply 56VDC - 201-26842	X
5.15 Delete recirculation power switching	Pad		Delete power switching provisions in ML S-II patch distributor, 202-220A1, and S-II power system distributor 201-265A2	X
5.16 Delete recording of recirculation power.	Pad LCC		Delete provisions for DDAS recording in S-II power systems distributor, 201-265-A2.	X
5.17 Delete recirculation pump motor inverters	Pad	Delete: V-21105		X
5.18 Provide engine ignition power from main bus	Pad			X

REQUIREMENTS CHANGE SHEET 5 ELECTRIC POWER		Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	X	Hardware Change	Procedure Change
REQUIREMENTS CHANGE	CONFIGURATION: S-II/J-2S WITH ONE RESTART						
5.19	Make same changes as for S-II/J-2S with no restart.		V-21249	See S-II/J-2S with no restart for impact	X		
5.20	Add power provisions for S-II APS				X		
5.21	Add APS module 1 & 2 power supply from S-II stage main power bus				X		
5.22	Add external control of APS power			Add APS power indication on S-II	X		
5.23	Delete S-II main battery and replace with larger battery.			V-21111 V-21249 V-21101	X		
5.24	Receive new battery.				X		
5.25	Service new battery.				X		
5.26	Install new battery.				X		

REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
			Procedure Change	Hardware Change
6.0 Modify the KSC capability for servicing and c/o of the Flight Control System due to the following:	All		Electrical functions and instrumentation requirements are covered in Requirements Change Sheets 5, 6, 10 and 12.	X
a. Addition of idle mode operation.				
b. Increase engine turbine speed				
c. Deletion of chilldown pumps.				
d. Increased coast duration during Synchronous Mission.				
6.1 Auxiliary hydraulic pump and accumulator are modified to supply all required flow during idle mode for 100 seconds duration and at thrust levels of 1350 and 5000 lbs maximum.	VAB Pad	V-24090 V-24091 S-V-24107 V-20017 V-20060	1. Procedure change only.	X
6.2 Modify hydraulic pump to delete requirement for 310 seconds start lead time because chilldown pumps are deleted.	VAB Pad	V-24090 V-24091 S-V-24107 V-20060	1. Procedure change only.	X
6.3 Increased coast duration requires additional heating cycles on the hydraulic pump. (S-IVB only.)	VAB	V-24090 V-24091 S-V-24107 V-20017 V-20060	1. Procedure change only.	X

REQUIREMENTS CHANGE SHEET 6 FLIGHT CONTROL SYSTEM (S-II and S-IVB)				
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
Hardware Change				
Procedure Change				X
Hardware Change				X
6.4 Provide mixing cycle of 48 seconds at every hour unless a heating cycle is required at that time. (S-IVB only.)	VAB Pad	V-24090 V-24091. S-V-24107 V-20017 V-20060	1. Procedure change only.	
6.5 Provide heating cycle of 480 seconds duration every 3 hour period. (S-IVB only).	VAB Pad	V-24090 V-24091. S-V-24107 V-20017 V-20060	1. Procedure change only.	

## REQUIREMENTS CHANGE SHEET 7 PNEUMATIC CONTROL &amp; PURGE SYSTEM

REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT
		Procedure Change Hardware Change	
7.0 Modify the KSC capability for servicing & c/o of the Pneumatic Control & Purge System due to the following:	AII		
a. Deletion of engine recirculation requirements b. Addition of idle mode c. Changes to the engine start system d. Addition of LOX dome purge e. Changes to thrust chamber jacket purge f. Addition of Reaction Control System (S-II only)	S-II STAGE	V-29030 V-25309 V-24247 O-V-24339 V-24258 V-24253 V-24254 V-24326	<p>1. Modify C7-53 Pneumatic C/O Blanking Plate, GSE Stage Umbilical, S-II Pneumatic Regulation &amp; Distribution Console (S7-41A), S-II Pneumatic Activation Purge &amp; C/O Console (S7-41C) &amp; Facility Plumbing.</p> <p>1. LOX dome purge capability shall be provided using He at <math>\frac{475}{475}</math> psig and between +50 to +150°F</p>

 Electrical System Functions & Instrumentation requirements are listed in Change Sheets 59, 10 & 12.

REQUIREMENTS CHANGE SHEET 7				PNEUMATIC CONTROL & PURGE SYSTEM
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
7.2 Thrust chamber purge shall be provided using He at 150±25 psig and between +50 to 150°F.		V-24258 V-24253 V-24254 V-24326 O-V-24329 V-24247 V-25309 V-29030	2. Heat Exchanger (A7-71), S-II Pneumatic Regulation & Distribution Panel (S7-41A), S-II Pneumatic Control Console (S7-41B)	x x
7.3 Delete all functions associated with the engine start tank and recirculation.	VAB Pad	V-24258 V-24253 V-29030 V-24326 O-V-24339 V-24247 V-25309	1. Modify GSE S-II Pneumatic Activation Purge & C/O Console (S7-41C), S-II LH <sub>2</sub> Servicing Console (S7-41D), Model A7-41 Aft Umbilical Carrier Plate, I A7-71 LH <sub>2</sub> Heat Exchanger.	x
7.4 Eliminate requirement for LOX chilldown pump purge.	VAB Pad	V-24258 V-24253 V-24326 O-V-24339 V-24247 V-25309 V-29030	1. Procedure change only	x
7.5 Since engine pump purge is only required prior to liftoff, thermal conditioning of the pneumatic bottle is not required prior to liftoff.		V-24258 V-24253 V-24326 O-V-24339 V-24247 V-25309 V-29030	1. Procedure change only	x

REQUIREMENTS CHANGE SHEET 7				PNEUMATIC CONTROL & PURGE SYSTEM	GSE/ESE IMPACT	
REQUIREMENTS CHANGE		Facility	PROCEDURES AFFECTED			
7.6	Provide 3000 psi GHe to the new S-II APS helium storage tank at 1#/Min. capability	VAB Pad	V-24258 V-24253 V-24326 O-V-24339	1. Modify the S-II Pneumatic Regulation & Distribution Panel (S7-41A) Umbilical, Umbilical Connector, A7-41 Heat Exchanger, Facility Plumbing, and S7-41 Pneumatic Service Console.	x	x
7.7	Provide 0 - 500 psi GN <sub>2</sub> to the APS system for maintaining the modules between 80 - 105°F.		V-24258 V-24253 V-24326 O-V-24339	1. Procedure change only	x	
7.8	Provide 0 - 500 psi GN <sub>2</sub> for fuel and oxidizer purge	VAB Pad	V-29030 V-25309 V-24247 V-24258 V-24253 V-24254 V-24326 O-V-24339	1. Modify Facility Plumbing to provide GN <sub>2</sub> to aft skirt via MSS	x	x
7.9	Helium is tapped off the Stage Vent Valve Actuation System to purge balanced vent system	VAB Pad	V-24258 V-24253 V-24254 V-24326 V-24247 O-V-24339 V-29030 V-25309	1. Procedure change only	x	

REQUIREMENTS CHANGE SHEET 7				PNEUMATIC CONTROL & PURGE SYSTEM
REQUIREMENTS CHANGE		Facility	PROCEDURES AFFECTED	GSE / ESE IMPACT
7.10	Convert valve actuation system from 3000 psi to 725 psi	VAB Pad	V-24258 V-24253 V-24254 V-24326 V-24247 O-V-24339 V-29030 V-25309	1. Procedure change only  x
7.11	Provide LH <sub>2</sub> fuel duct purge	VAB Pad	V-24258 V-24253 V-24254 V-24326 V-24247 O-V-24339 V-25309	1. Procedure change only  x
<u>S-IV STAGE</u>				
7.12	LOX Dome Purge capability shall be provided using He at 475±25 psig and between +50 to +150°F.	VAB Pad	V-24090 V-24091 S-V-24107 V-24344 S-V-26003 V-35015	1. Modify GSE Stage Umbilical, Oxidizer Dome Purge (Mod 432A), and Facilities Plumbing.  x
7.13	Thrust Chamber Purge shall be provided using He at 150±25 psig and between +50 to +150°F.	VAB Pad	V-24090 V-24091 S-V-24107	1. Modify GSE Mod 438A and Mod 433A to provide ambient temperature He at revised pressure requirements.  x

REQUIREMENTS CHANGE SHEET		7		PNEUMATIC CONTROL & PURGE SYSTEM	
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED		GSE/ESE IMPACT	
7.14 Delete all functions associated with the engine start tank and recirculation.	VAB Pad	V-21268 V-24090 V-24091 S-V-24107 S-V-26003 O-V-24095 V-24212	1. Modify GSE Mod 432A, 433A and 438A to eliminate all GH <sub>2</sub> and He supply and vent functions associated with engine start tank.	x	x
7.15 Eliminate the requirement for LOX Chilldown Pump Purge.	VAB Pad	V-20017 V-20010 S-V-24107 V-21264 V-21263 V-21268 V-20060 V-24090 V-24091 O-V-24095	1. Procedure change only	x	
7.16 Since engine pump purge is required prior to liftoff only, thermal conditioning of pneumatic bottle is not required prior to liftoff.	VAB Pad	V-24090 V-24091 S-V-24107	1. Procedure change only	x	
7.17 Delete requirement for pre-valve actuation.	VAB Pad	S-V-24107 V-24090 V-20017 V-24106	1. Procedure change only	x	

REQUIREMENTS CHANGE SHEET 8		ENVIRONMENTAL CONTROL SYSTEM		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
			x	Change Hardware
8.0 Modify KSC capability to service and c/o the Environmental Control System changes resulting from:	VAB PAD			
a. S-IVB with two restart capability associated with Synchronous Mission.				
b. S-II with one restart capability associated with Low Earth Orbit Mission.				
8.1 Provide air atmosphere to the TYC motor by pressurizing two air bottles on the S-II engine.	VAB PAD	V-20017 V-24243 V-24245 0-V-26441 0-V-24256 S-V-24311 V-27246 V-24160 V-24253 V-25164 V-25307 V-24124 V-24244 V-24254 V-24326 0-V-26350 0-V-24339 V-24247		1. Modify S7-41 Pneumatic Service Console, A7-41 Aft Umbilical Carrier Plate, Umbilical , and facility plumbing and tanking to provide air bottle fill and c/o capability.

 Electrical functions and instrumentation requirements associated with Environmental Control System are covered on requirement sheets 5, 9, 10 and 12.

REQUIREMENTS CHANGE SHEET 8		ENVIRONMENTAL CONTROL SYSTEM (CONTINUED)		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
8.2 The ambient helium bottle shroud and conditioning duct is removed and the helium bottle outlet duct is capped.		V-24160 V-24244 V-25250 V-24245 V-24243 V-20017	1. Procedure only.	x
				Hardware Change
				Procedure Change

REQUIREMENTS CHANGE SHEET 9		ELECTRIC CONTROL SYSTEM		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
CONFIGURATION:				Hardware Change
S-IVB/J-2S WITH ONE <u>RESTART</u>	TCC VAB LCC PAD	V-29053 V-21086 Delete the following: 0-V-29113 0-V-29016 0-V-39003 0-V-29056 0-V-39000 0-V-39002	X X X X	On EBW and Ordnance Panel, 601-409A1 delete: ullage rocket firing unit enable indication and switching ullage rocket ignition and jetti- son firing unit charge voltage meters ullage rocket ignition and jetti- son pulse sensor fired indicators
1. Delete ullage rockets				
2. Delete ullage rocket switch selector channels.				
3. Delete ullage rocket command interface with IU				
4. Delete ullage rocket command interface with S-II				
5. Delete ullage rocket external controls, indications and metering	LCC PAD			

REQUIREMENTS CHANGE SHEET 9		ELECTRIC CONTROL SYSTEM (CONTINUED)			
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT		
CONFIGURATION: S-IVB/J-2S WITH ONE RESTART (CONTINUED)					
5. (Continued)					X
6. Add Solid Propellant Turbine Starter (SPTS) (2)	LCC TCC Low Bay PAD	New procedures as required to cover SPTS handling, check- out, test, etc.	On EBW and Ordnance Panel, 601-409A1, add: SPTS EBW ready indication SPTS EBW fired indication SPTS EBW voltage meter (SPTS EBW fired indication and voltage meter for 1 unit only) On TCC Engine Test Panel, add: main stage start solenoid indica- tion		X
7. Add SPTS external control indica- tions and metering					
8. Delete APS ullage engine	TCC VAB LCC PAD	V-27217 V-21083 V-23137 V-24092 V-24266 O-V-24184 IV-21241			

REQUIREMENTS CHANGE SHEET 9		ELECTRIC CONTROL SYSTEM (CONTINUED)		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	Procedure Change Hardware Change
9. Delete APS ullage engine command interface with IU				X
10. Delete APS ullage engine external controls			On EBW and Ordnance Panel, 601-409A1, delete: indication of ullage engine relay reset	X
11. Delete LOX depletion sensor	TCC Low Bay LCC PAD	V-21073 V-27145	On Engine Test Panel, 601-406A5, delete: switches to simulate LOX sensors wet wet indication of LOX sensors wet On TCC Propellant Level Monitor Panel delete: switches to simulate LOX sensors wet wet indication of LOX sensors wet On Event Display Panel delete: LOX cutoff sensor wet indicators	X
12. Delete recirculation/chilldown	LCC PAD TCC Low Bay	IV-21267 V-26002 V-24091 V-27104 S-V-26003 V-20017 V-20049 S-V-24095 V-21264 V-24090 V-24212 V-20010	Delete entire Recirculation Panel, 601-406A1 On Networks Panel, 601-405A1, delete: LOX & LH <sub>2</sub> chilldown inverter power and relay reset indication On Engine Test Panel, 601-406A5, delete: LOX Bleed Valve indication. On Networks Panel, 601-405A1, delete: chilldown pump safe indication On Engine Preparation Panel, 601- 406A6, delete: engine thrust chamber jacket temperature indication	X

REQUIREMENTS CHANGE SHEET 9		ELECTRIC CONTROL SYSTEM (CONTINUED)		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
12. (Continued)		Delete: IV-21267	chilldown valve control and indication On Events Display Panel, delete: prevaleve emergency close indication & LOX & LH <sub>2</sub> chilldown indication & chilldown inverter power controls On TCC Stage Pressure Panel, delete: chilldown and prevalve switching and indication	x
13. Delete gas generator power and control	TCC LCC PAD Low Bay	V-24125 V-24091 V-27104 V-21377 V-21343	On Engine Test Panel, 601-406A5, delete: gas generator spark system indica- tion gas generator valve solenoid indication ignition phase ignition indication On TCC Engine Test Panel, delete: gas generator spark system test switch and activation switch gas generator valve indication gas generator spark indication	
14. Delete start tank	LCC PAD Low Bay High Bay TCC	V-24091 V-27104 V-26002 O-V-24295 V-24090 V-24212 V-24344 V-20010	On Helium Control Panel, 601-406A3, delete: start tank purge switch and indi- cation On GH/GN Control Panel, 601-406A4, delete: GH supply valve control, indication and metering GH heat exchanger vent control and indication On Engine Test Panel, 601-406A5, delete: start tank valve control and indication	x

## REQUIREMENTS CHANGE SHEET 9

REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	Hardware Change	Procedure Change
14. (Continued)			<p>LOX turbine bypass valve position indication engine pump purge pressure indication On Engine Preparation Panel, 601-406A6, delete: start tank supply, purge and vent valve control and indication start tank pressure and temperature metering engine and start tank temperatures and pressures</p> <p>On TCC Engine Test Panel, delete: start tank control and indication start tank pressure metering related fuel and LOX valve indication pump seal purge metering</p>	X	
15. Overall change to S-IVB to support above detailed changes	LCC LUT PAD	V-21260 V-21380 V-21257 V-27046 V-24084 V-21269 V-24213 V-21342 V-21378 V-20027 V-20010 O-V-21251	<p>Modify LUT Patch Distributors Forward and Aft Crossover Distributors, LCC Patch Distributors and Swing Arm 6 to remove or add jumpers as required to by above panel changes.</p>		Provide new software as required for 110A, DDAS, DEE-3 and S-IVB PTCS.

REQUIREMENTS CHANGE SHEET 9				ELECTRIC CONTROL SYSTEM (CONTINUED)		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	Procedure Change	Hardware Change	Change
<p>CONFIGURATION: S-IVB/J-2S WITH TWO RESTARTS</p> <p>1. Same as S-IVB/J-2S with one restart, items 1 through 16</p> <p>2. Add 3 SPTS, SPTS EBW firing units, EBW detonators, external controls, indication and monitoring</p> <p>3. Same as S-IVB/J-2S with one restart, items 8 through 15</p>			<p>See S-IVB/J-2S with one restart for procedures affected</p> <p>See S-IVB/J-2S with one restart, item 7</p> <p>See S-IVB/J-2S with one restart for procedures affected</p> <p>See S-IVB/J-2S with one restart for impact</p> <p>X</p>			

REQUIREMENTS CHANGE SHEET 9		ELECTRIC CONTROL SYSTEM (CONTINUED)			
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT		
CONFIGURATION: S-III/J-2S WITH NO RESTARTS			X	X	X
1. Delete ullage rocket power distribution system and ullage rocket controls		0-V-29032 V-27197 V-29028 0-V-29054 0-V-29053 V-29023 Delete: 0-V-29022			
2. Delete ullage rocket switch selector and separation controller channels					
3. Delete ullage rocket command interface with IU					
4. Delete ullage rocket external controls, indication and metering	LCC				
5. Modify LOX depletion cutoff to provide multi-engine cutoff arming					
			On EBW and Ordnance Panel, 601-209A2 delete: ullage rocket charge voltage metering		
			On Events Display Panel delete: ullage rocket events displays.		
			On Propellant Depletion Panel, 601-206A14, delete: LOX depletion indication and arming switch LOX open and dry indications LH <sub>2</sub> open and dry indications wet, dry and open simulation switches		

REQUIREMENTS CHANGE SHEET 9		ELECTRIC CONTROL SYSTEM (CONTINUED)			
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT		
			Procedure Change Hardware Change	Procedure Change Hardware Change	Procedure Change Hardware Change
5. (Continued)					
6. Add SPTS external control indication and metering	LCC	Add new procedures to process, check-out and install SPTS	LH <sub>2</sub> depletion indication and arming switch	To EBW and Ordnance Panel, 601-209A2, add: SPTS ready indications (5) SPTS EBW meter (1) SPTS fired indication (1) On TCC Panel, add SPTS indication	X
7. Delete recirculation/chilldown external control and indication	LCC	V-21105 V-24247 V-24125 V-24124 V-20010 V-20017 V-20049	On Networks Panel, 601-205A1, delete: recirculation power control and indication On Pneumatics Panel, 601-206A10, delete: chilldown and recirculation valve control and indication On all Engine Panel, 601-206A6, delete: thrust chamber chilldown control and indication thrust chamber purge control and indication thrust chamber temperature select switch Delete Recirculation Panel, 601-206A11 On Events Display Panel, delete: recirc/chilldown indication	X	

REQUIREMENTS CHANGE SHEET 9		ELECTRIC CONTROL SYSTEM (CONTINUED)		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	Procedure Change Hardware Change
8. Delete Gas Generator Controls and External Control, Power and Indication	LCC	V-21104	On Engine Panels, 601-206A1, 601-206A2, 601-206A3, 601-206A4, and 601-206A5, delete: gas generator spark exciter control and indication gas generator valve indication ignition phase solenoid control switch	X
9. Delete Start Tank	LCC	V-24116 V-24117 V-24125 V-24247 V-20010	On Pneumatics Panel, 601-206A10, delete: GH supply valve switch and indication GH pressure indication Start tank line vent switch and indication start tank pressure vent switch and indication On Engine Panels, 601-206A1, 601-206A2, 601-206A3, 601-206A4, and 601-206A5, delete: start tank valve switch and indication start tank pressure metering helium bottle pressure metering On all Engine Panel, 601-206A6, delete: turbine start bottle pressure switch and indication start tank vent switches and indications turbine start tank vent switch and indication all helium bottle and start tank purge switch and indication	X

REQUIREMENTS CHANGE SHEET 9		ELECTRIC CONTROL SYSTEM (CONTINUED)		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	Procedure Change Hardware Change
9. (Continued)				
10. Modify prevalve controls to provide prevalve closing only on emergency cutoff				
11. Overall change to S-II resulting from detail changes above	LUT LCC	0-V-21251 V-27154 V-21065 V-21028 V-21107 V-21068 V-21069 V-21067	Modify LUT Patch Distributors, Forward and Aft Crossover Distributors, LCC Patch Distributors and Swing Arm	X
			Modify TCC ESE	Provide new software as required for 110A, DDAS, DEE-3 and S-II PTCS

REQUIREMENTS CHANGE SHEET 9		ELECTRIC CONTROL SYSTEM (CONTINUED)		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
CONFIGURATION: S-II/J-2S WITH ONE RESTART				
1. Same as S-II/J-2S with no restart, all items		See S-II/J-2S no restart for procedures affected	See S-II/J-2S with no restart for impact	X
2. Add Auxiliary Propulsion System (APS)	Low Bay High Bay PAD LCC	New procedures as follows: APS Module Preservation Test APS Electrical Interference Compatibility Test Function Test of APS Signal Recording System APS Module Lab Checkout APS Module Subsystem checkout-stage mounted APS Module Handling APS Lab Checkout equipment verification	Add S-II APS Pneumatic Panel, similar to S-IVB APS Pneumatic Panel, 601-419A2 in LCC On Networks Panel, 601-205A1, add: APS power indication	
3. Add OTV coverage of APS Servicing operations	Pad MSS		Relocate two (2) OTV cameras, formerly used for S-IVB APS coverage, to view S-II APS servicing	X
4. Add OIS stations adjacent to APS and to APS Servicing equipment	Pad MSS		Add OIS stations adjacent to APS and to APS Servicing equipment	X

REQUIREMENTS CHANGE SHEET 10		INSTRUMENTATION & TELEMETRY SYSTEM		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
			Hardware Change	Procedure Change
CONFIGURATION: S-IVB/J-2S WITH ONE RESTART				
10.1 Delete instrumentation related to start tank, recirculation, chilldown, APS ullage, gas generator, prevalves, ullage rocket firing and jettison - total of 56 measurements	Low Bay	V-27106 V-28178 V-21267	None identified	x
10.2 Add instrumentation related to SPTS, engine idle mode - total of 57 measurements		V-27106 V-28178	None identified	x
CONFIGURATION: S-IVB/J-2S WITH TWO RESTARTS				
10.3 Delete instrumentation related to start tank, recirculation, chilldown, APS ullage, gas generator, prevalves, ullage rocket firing and jettison - total of 56 measurements	Low Bay	V-28178 V-21267	None identified	x
10.4 Add instrumentation related to SPTS, engine idle mode - total of 62 measurements		V-28178	None identified	x
10.5 Add two Model 270 Multiplexers, two Low Level Remote Analog Submultiplexers, two signal conditioning racks, one tape recorder			None identified	x

REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	INSTRUMENTATION & TELEMETRY SYSTEM	
			GSE/ESE IMPACT	Hardware Change
10.6 Reprogram Model 301 PCM/DDAS Assembly for time sharing three Model 270 Multiplexers			None identified	x
10.7 Add RF power amplifier			None identified	x
CONFIGURATION: S-II/J-2S WITH NO RESTART				
10.8 Delete instrumentation related to start tank, recirculation, chilldown, gas generator, ullage rockets - total of 128 measurements		S-V-28133 V-27115 V-28142 V-24114 V-28075 V-28074 V-27148 V-27114 V-27148	None identified	x
10.9 Add instrumentation related to SPTS, engine idle mode, engine emergency cutoff - total of 139 measurements		O-V-28143	None identified	x
CONFIGURATION: S-II/J-2S WITH ONE RESTART				
10.10 Delete instrumentation related to start tank, recirculation, chilldown, gas generator, ullage rockets - total of 128 measurements		V-27115 V-28142 V-24114 V-28075 V-27114	None identified	x

REQUIREMENTS CHANGE SHEET 10 INSTRUMENTATION & TELEMETRY SYSTEM				Hardware Change	Procedure Change
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT		
10.11 Add instrumentation related to SPTS, engine idle mode, emergency engine cutoff, APS system operation - total of 215 measurements		V-28073	None identified	x	

REQUIREMENTS CHANGE SHEET 11		LOX & LH <sub>2</sub> PRESSURIZATION SYSTEM		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
S-IVB ONE OR TWO RESTARTS				
11.1 Modify KSC facilities and GSE to supply ambient helium only for propellant tank pressurization and for filling stage helium storage bottles.	LUT	V-24090 V-26002 S-V-24095 V-24212	De-activate chilldown function of LH <sub>2</sub> heat exchanger console 438A and revise c/o procedures.	x
11.2 Modify KSC facilities and GSE to checkout in-flight hydrogen tank pressurization system for 1350 psia maximum operating pressure.	LUT	V-24090	Revise leak test equipment and procedures to reflect higher operating pressures.	x
S-II ONE OR NO RESTART				
11.3 Modify KSC facilities and GSE to checkout in-flight hydrogen pressurization system for 1350 psig maximum operating pressure.	LUT	V-25164 V-25307 O-V-25385	Revise leak test equipment and procedures to reflect higher operating pressures.	x
S-II ONE RESTART				
11.5 Modify KSC facilities and GSE to checkout propulsive vent system on LH <sub>2</sub> tank.		V-24116	Revise vacuum check procedures to add propulsive vent system check.	x

REQUIREMENTS CHANGE SHEET	12	IU SYSTEM	GSE/ESE IMPACT	
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED		
CONFIGURATION: S-IVB/J-2S WITH ONE RESTART				
12.1 Change software		None	None	x
CONFIGURATION: S-IVB/J-2S WITH TWO RESTARTS				
12.2 Change software			None	x
12.3 Replace 3-350 AH batteries in IU with 4-470 AH batteries	Ped	IV-21254	None	x
12.4 Modify IU power amplifiers			None	
CONFIGURATION: S-II/J-2S WITH NO RESTART			None	
12.5 Change software			None	
CONFIGURATION: S-II/J-2S WITH ONE RESTART				
12.6 Interconnect IU & S-II Measuring & Telemetry Systems	High Bay	V-21228 IV-21248 V-21369 V-21371	None	
12.7 Change software			None	
12.8 Reroute S-IVB APS circuits to S-II stage APS	High Bay	V-23175	See Electric Control System, sheet 9, S-II/J-2S with one restart for APS changes	x

REQUIREMENTS CHANGE SHEET		13	GAS GENERATOR SYSTEM	
REQUIREMENTS CHANGE		Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT
S-IVB ONE OR TWO RESTARTS				Control and monitor panels in the LCC and TCC will be modified as stated in requirements change sheet 9.
13.1	Modify KSC facilities and GSE to delete all functions associated with the Engine Gas Generator System.			x
13.2	Revise procedures associated with Gas Generator Checkout listed below as well as any other related procedures.			x
	P. C. Card Spark Monitor Timer Qualification Low Bay	V-21377	Delete procedure	x
	P. C. Card Calibration	V-21343	Delete procedure	x
	Electrical System Pad/LCC Interface Verification	V-21261	Revise procedure	x
	S-IVB/V Panel Lamp Verification	V-21370	Revise procedure	x
<u>S-II ONE OR NO RESTART</u>				
13.3	Modify KSC facilities and GSE to delete all functions associated with the Engine Gas Generator System		Control and monitor panels in the LCC and TCC will be modified as stated in requirements change sheet 9.	x
13.4	Revise procedures associated with Gas Generator Checkout listed below as well as any other related procedures.			x
	Engine C/O Leak and Functional Test (Low Bay)	V-24124	Revise procedures	x

REQUIREMENTS CHANGE SHEET		13	GAS GENERATOR SYSTEM	
REQUIREMENTS CHANGE		Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT
13.4	(Continued)		V-21104	Revise procedures
	ASI and GG Spark Monitor System Functional Check			x

REQUIREMENTS CHANGE SHEET 14 ENGINE START SYSTEM		PROCEDURES AFFECTED	GSE/ESE IMPACT	Procedure Change	Hardware Change
REQUIREMENTS CHANGE	Facility				
Modify the KSC capability to install, service, and c/o the new SPTS Start System.	VAB Pad	Add 3 new procedures Modify O-V-20032 V-30539 V-24090 V-24091 S-V-24107 V-20017 V-24106 V-20004 V-211C3 V-24247 V-27246 S-V-24311 O-V-24256 O-V-26350 V-24248	<ol style="list-style-type: none"> <li>1. Provide new storage, handling, and installation equipment for the SPTS and for the SPTS ignitors.</li> <li>2. Provide new or modified procedures for handling, installing, and c/o of SPTS and ignitor, and S-IVB/S-II stage with SPTS/ignitor installed.</li> </ol> <p style="text-align: center;">1</p>	x x	x x

 Electrical Systems functions and instrumentation requirements are listed in Requirement Change Sheets 5, 9, 10 & 12

REQUIREMENTS CHANGE SHEET 15				J-2S ENGINE
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
S-II & S-IVB	All			
15.1	Modify KSC facilities and GSE for handling, servicing and checkout of the J-2S engine	In addition to the J-2S requirements changes listed in the preceding change sheets, the following items are considered to have significant KSC impact	X	X
15.2	Modify KSC facilities and GSE to be compatible with the J-2S physical envelope, i.e., structure, plumbing, and electrical	O-V-26236 O-V-26237 O-V-24119		
15.3	Revise operating procedures for KSC functions related to J-2S servicing and checkout not satisfied by preceding requirement change sheets:			
	Engine C/O (low bay) leak check and functional test	V-24124	X	
	Engine actuation system - stage oriented GSE install and remove	0-V-26350	X	
	Engine actuation system - functional checkout	V-24247	X	
	Engine actuation system - servicing and configuration requirements	V-24246	X	

REQUIREMENTS CHANGE SHEET 15		J-2S ENGINE (CONTINUED)		
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	
			Procedure Change Hardware Change	Procedure Change Hardware Change
15.2 (Continued)			X	X
Engine actuation system - flight control and guidance test		S-V-24311		
Engine system leak and functional test (high-bay)		V-24117		
Setup and calibration procedures for support of engine system valve timing sequence		S-V-27149		
Engine system valve timing sequence test		V-24125		
Engine clearance and EAS servo actuation hydraulic lock test procedure		V-24248		
Engine system V/V timing sequence test		V-24125		
Engine compartment conditioning system install		V-24243		
Engine sequencer test		V-24091		
Instrumentation setup procedures - S-IVB engine sequence test		V-27104		

REQUIREMENTS CHANGE SHEET 15 J-2S ENGINE (CONTINUED)					
REQUIREMENTS CHANGE	Facility	PROCEDURES AFFECTED	GSE/ESE IMPACT	Procedure Change	Hardware Change
15.2 (Continued)				X	X
Engine Safety Circuits Test	V-21100				
Engine removal	UNK				

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**APPENDIX E**  
**ELECTRICAL BACK-UP**

## APPENDIX E - REQUIREMENT CHANGE IMPACT ON ESE

## S-IVB REQUIREMENT CHANGES

REQUIREMENTS CHANGE SHEET	MODIFICATIONS	S-IVB ESE ELECTRICAL SCHEMATIC 40M13870
Delete Ullage Rockets  (Page 1 Item 5)	<ul style="list-style-type: none"> <li>a) Reidentify DS4 as SPTS #1 EBWS #1 Fired</li> <li>b) Reidentify DS5 as SPTS #1 EBWS #2 Fired</li> <li>c) Reidentify DS6 as SPTS #2 EBWS #1 Fired</li> <li>d) Reidentify DS7 as SPTS #2 EBWS #2 Fired</li> <li>e) Add 2 similar circuits, identify as SPTS #3 EBWS #1 Fired and SPTS #3 EBWS #2 Fired, use 2 DDAS channels</li> <li>f) Delete Events Display Panel circuitry</li> <li>g) Reidentify M1 as SPTS #3 EBWS #1 Charge Voltage</li> <li>h) Reidentify M2 as SPTS #3 EBWS #2 Charge Voltage</li> <li>i) Delete M3, M4 and associated circuitry</li> <li>j) Reidentify DS3 as SPTS #1 Ready (Green)</li> <li>k) Delete Events Display Panel circuitry</li> <li>l) Delete S3 and associated circuitry</li> </ul>	<p>Sheet 316</p> <p>Sheet 315</p> <p>Sheet 318</p>

## APPENDIX E - REQUIREMENT CHANGE IMPACT ON ESE

## S-IVB REQUIREMENT CHANGES

REQUIREMENTS CHANGE SHEET	MODIFICATIONS	S-IVB ESE ELECTRICAL SCHEMATIC 40M13870
Add SPTS (Page 2 Item 7)	a) Add 2 indicators labeled SPTS #2 Ready, SPTS #3 Ready  b) Add 2 new data channels and DEE inputs  c) Add 2 indicators labeled SPTS #3 EBWS #1 Fired SPTS #3 EBWS #2 Fired  d) Pick-up 2 A/B DDAS Channels to drive indicators  e) Reidentify M1, M2 per Page 1 Item 5 above	Sheet 318  Sheet 316  Sheet 315
Delete APS Ullage Engine (Page 3 Item 10)	f) Delete DS7 and associated circuitry	Sheet 289, 290
Delete LOX Depletion System (Page 3 Item 11)	g) Delete S38, S39, DS70, DS71 and associated circuitry  h) Delete S40, DS72, Contact 1 of S37 and associated circuitry  i) Reidentify DS69 as LH Cutoff Sensor No. 4 Wet	Sheet 236  Sheet 237
Delete Recirc/ Chilldown (Page 3 Item 12)	j) Delete Recirculation Panel and associated circuitry  k) Delete DS27, DS18, and associated circuitry  l) Delete DS31, DS20, DS29, and associated circuitry  m) Delete M6 and associated circuitry  n) Delete S13, DS21, DS27 and associated circuitry	Sheet 301-308, 66, 170, 131, 362, 222, 172, 336  Sheet 49  Sheet 66, 76, 77  Sheet 218  Sheet 220

**APPENDIX E - REQUIREMENT CHANGE IMPACT ON ESE**  
**S-IVB REQUIREMENT CHANGES**

REQUIREMENTS CHANGE SHEET	MODIFICATIONS	S-IVB ESE ELECTRICAL SCHEMATIC 40M13870
Delete Gas Generator (Page 4 Item 13)	a) Delete DS36 and associated circuitry b) Delete DS32 and associated circuitry (See Page 3 Item 14 f) c) Delete DS34 and associated circuitry d) Delete S17, DS10, DS14 and associated circuitry e) Delete S16, DS27, DS29 and associated circuitry f) Delete M7, M8 and associated circuitry g) Delete S11, DS23, DS26 and associated circuitry h) Delete S14, DS22, DS30, DS38 and associated circuitry i) Delete DS24, DS16 and associated circuitry j) Delete DS17, M5 and associated circuitry k) Delete S6, DS6, DS14 and associated circuitry l) Delete S7, DS7, DS15 and associated circuitry m) Delete S8, DS8, DS16 and associated circuitry n) Delete M3, M4, M6 and associated circuitry	Sheet 224 Sheet 228 Sheet 223 Sheet 93 Sheet 100 Sheet 108 Sheet 101 Sheet 227, 215, 217 Sheet 228 Sheet 211 Sheet 215 Sheet 216 Sheet 217 Sheet 218

## APPENDIX E - REQUIREMENT CHANGE IMPACT ON ESE

## S-IVB REQUIREMENT CHANGES

REQUIREMENTS CHANGE SHEET	MODIFICATIONS	S-IVB ESE ELECTRICAL SCHEMATIC 40M13870
Delete Gas Generator (Continued)  Functions Identified in D5-15772-2	a) Delete M1, M2 and associated circuitry  b) Delete Switch Position #1 on M5  c) Reidentify DS2 as SPTS Armed (Red)  d) Reidentify DS28 as SPTS Arms (Red)	Sheet 214  Sheet 109  Sheet 317  Sheet 51

## APPENDIX E - REQUIREMENT CHANGE IMPACT ON ESE

## S-II REQUIREMENT CHANGES

REQUIREMENTS CHANGE SHEET	MODIFICATIONS	S-II ESE ELECTRICAL SCHEMATIC 40M10590
Delete Ullage Rockets (Page 7 Item 4)	a) Reidentify DS1, DS7 as SPTS EBWS #1 and #2 Fired	Sheet 387
Modify LOX Depletion (Page 7 Item 5)	b) Reidentify M1 and M2 as SPTS EBWS #1 and #2 Charge Voltage	Sheet 389
	c) Delete DS1, 9, 17, 25, S1 and associated circuitry	Sheet 367, 374
	d) Delete DS2, 10, 18, 26, S2 and associated circuitry	Sheet 368, 374
	e) Delete DS3, 11, 19, 27, S3 and associated circuitry	Sheet 369
	f) Delete DS4, 12, 20, 28, S4 and associated circuitry	Sheet 370
	g) Delete DS5, 13, 21, 29, S5 and associated circuitry	Sheet 371
	h) Delete DS6, 7, 14, 15, S6, S7 and associated circuitry	Sheet 372
	i) Delete S9, S10, S11 and associated circuitry	Sheet 374
Add SPTS (Page 8 Item 6)	j) Add 5 SPTS ready indications See P7 Item 4, above, for EBWS meter and fired indication	Sheet 387
Delete Recirc/ Chilldown (Page 8 Item 7)	k) Delete Module	Sheet 109
	l) Jumper K18 <u>I H</u> , K34 JJ KK	Sheet 107
	m) Disconnect K115V W from circuit	Sheet 107
	n) Disable K34, K35 coils Delete DS25	Sheet 106
	o) Delete DS20 and associated circuitry	Sheet 105

## APPENDIX E - REQUIREMENT CHANGE IMPACT ON ESE

## S-II REQUIREMENT CHANGES

REQUIREMENTS CHANGE SHEET	MODIFICATIONS	S-II ESE ELECTRICAL SCHEMATIC 40M10590
Delete Recirc/ Chilldown (Continued)	a) Remove jumper J46 CC to DD b) Delete S21 Disable Coil K28 c) Jumper K15 ED, Delete DS10 d) Delete M2 and associated circuitry e) Disable Recirc. Voltage Monitor f) Delete DS60, S35, and associated circuitry g) Delete S20, DS9 and associated circuitry h) Delete S21, DS10 and associated circuitry i) Delete S22 and associated circuitry j) Delete Recirc. Panel 601-206A11 and associated circuitry k) Delete DS13 and associated circuitry l) Delete DS14, DS15 and associated circuitry m) Delete S6 and associated circuitry n) Delete DS4, DS12 and associated circuitry o) Delete DS13 and associated Circuitry	Page 104  Page 103  Page 97  Page 95  Sheet 135  Sheet 277  Sheet 278  Sheet 286  27 sheets  Sheet 303  Sheet 305  Sheet 308  Sheet 311  Sheet 315
Delete Gas Generator (Page 9 Item 8)		

## APPENDIX E - REQUIREMENT CHANGE IMPACT ON ESE

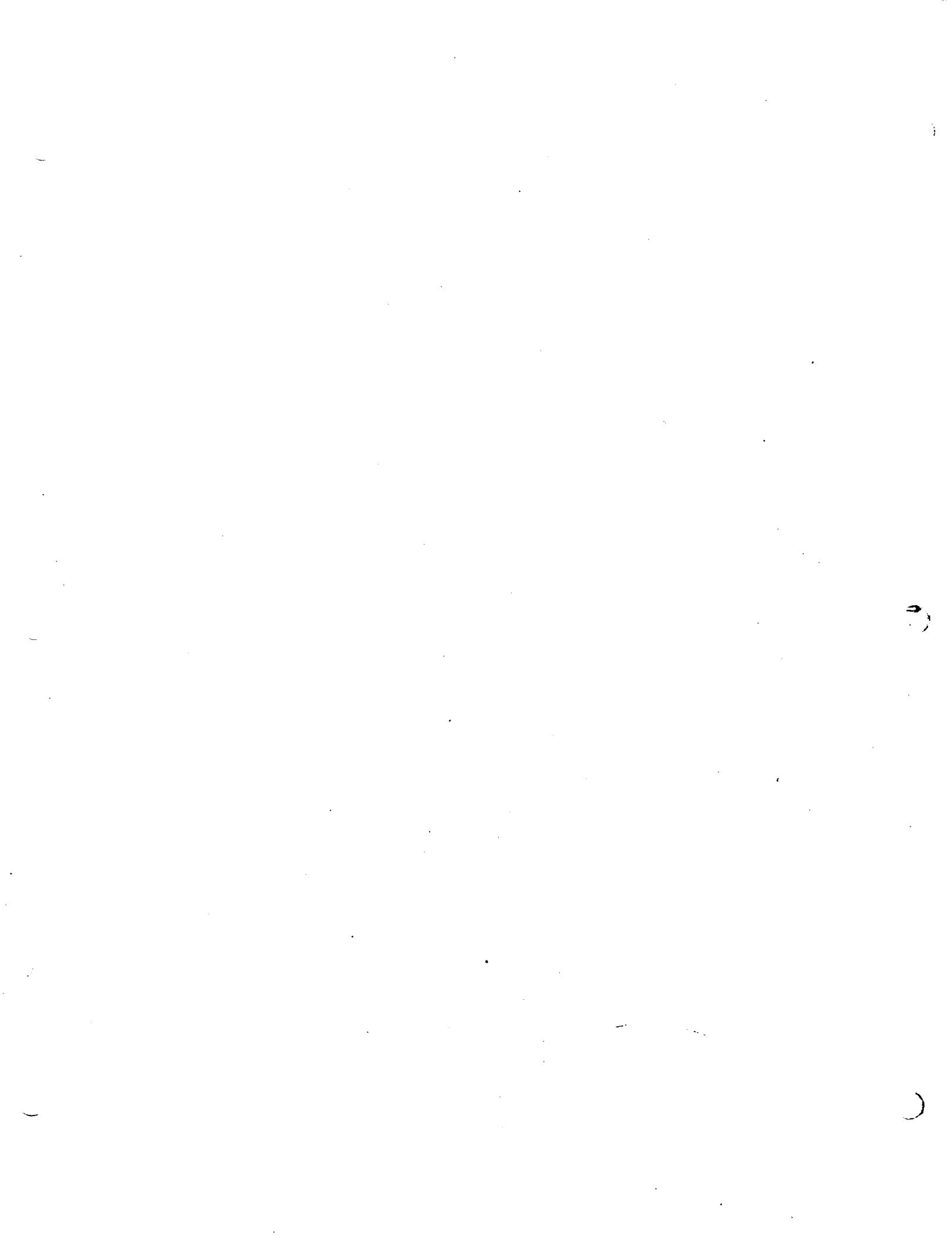
## S-II REQUIREMENT CHANGES

REQUIREMENTS CHANGE SHEET	MODIFICATIONS	S-II ESE ELECTRICAL SCHEMATIC 40M10590
Delete Gas Generator (Continued)	a) Delete DS14, DS15 and associated circuitry b) Delete S6 and associated circuitry c) Delete DS4, DS12 and associated circuitry d) Delete DS13 and associated circuitry e) Delete DS14, DS15 and associated circuitry f) Delete S6 and associated circuitry g) Delete DS4, DS12 and associated circuitry h) Delete DS13 and associated circuitry i) Delete DS14, DS15 and associated circuitry j) Delete S6 and associated circuitry k) Delete DS4, DS12 and associated circuitry l) Delete DS13 and associated circuitry m) Delete DS14, DS15 and associated circuitry n) Delete S6 and associated circuitry o) Delete DS4, DS12 and associated circuitry p) Jumper K283 NM	Sheet 317 Sheet 320 Sheet 323 Sheet 327 Sheet 329 Sheet 332 Sheet 335 Sheet 339 Sheet 341 Sheet 344 Sheet 347 Sheet 351 Sheet 353 Sheet 356 Sheet 359 Sheet 285

## APPENDIX E - REQUIREMENT CHANGE IMPACT ON ESE

## S-II REQUIREMENT CHANGES

REQUIREMENTS CHANGE SHEET	MODIFICATIONS	S-II ESE ELECTRICAL SCHEMATIC 40M10590
Delete Start Tank (Page 9 Item 9)	a) Delete S3, DS8, DS14, DS2 and associated circuitry b) Delete S36, DS61 and associated circuitry c) Delete S7, DS23, DS19 and associated circuitry d) Delete M1, M6 and associated circuitry e) Delete M2, M7 and associated circuitry f) Delete M3, M8 and associated circuitry g) Delete M4, M9 and associated circuitry h) Delete M5, M10 and associated circuitry i) Delete S9, DS4 and associated circuitry j) Delete S11, DS6 and associated circuitry k) Delete S13, S14, S15 and associated circuitry l) Delete S16, S17 and associated circuitry m) Delete S3 and associated circuitry n) Delete S4, S5, S6, S7, S8 and associated circuitry	Sheet 126  Sheet 134  Sheet 309, 321, 333, 345 357  Sheet 313  Sheet 325  Sheet 337  Sheet 349  Sheet 361  Sheet 270  Sheet 271  Sheet 272  Sheet 273  Sheet 274, 275  Sheet 276



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**APPENDIX F**  
**COST BACK-UP**

COST SUPPORT DATA

The Cost Backup Data displayed on the following pages define the basis of pricing both the Implementation (non-recurring) and Operations (recurring) activity of the LOR and LEO processing concepts.

Appendix thru define the basic pricing ground rules assumed for this cost study.

Appendix thru define the definition of cost elements, labor rate estimating, and manpower definition.

Appendix thru reflect manhour deletions or additions to change procedures required to support the LEO and LOR processing concepts. Vehicle 503 procedures are used as the base line.

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## COSTING ASSUMPTIONS AND GUIDELINES

Costs will be estimated in terms of 1969 dollar values.

Single-shift, standard 5-day work weeks will be assumed.

All overhead, burden, G&A, fee, and other similar costs will be included.

Costs for NASA administrative and technical overview of contractor implementation activities will not be included.

Costs will not be included for maintenance, service, and expendables associated with facility modification/installation - (i.e., water, electricity, guards, etc.)

Based on historical data, factors will be included for "make-work" revision but not for modifications to improve a workable system or to adapt the system to a new mission requirement.

All costs to be rounded to nearest \$100 or \$1,000 as magnitude permits.

Component and system cleaning is excluded from pricing data unless otherwise noted.

Design costs will include normal costs associated with original preparation and release of drawings, bill of materials, and specification.

Modification/installation costs will include costs of the bid cycle and of all material and equipment, construction, and installation. Continuing engineering costs incurred in support of these activities will also be included.

Activation Costs include all testing and "Make Operable" type modifications required to demonstrate an operational capability. Upon satisfactory completion of the OAT (Operational Acceptance Test) it is assumed that activation will be completed. Costs for design improvements and modifications updating the system, or modifications peculiar to one specific flight mission are excluded from this study.

Activation will be conducted using an Operational Vehicle (Not a Test Vehicle)

COSTING ASSUMPTIONS AND GUIDELINES  
(Continued)

Activation costs will exclude that portion of effort deemed to be applicable to flight operations where Operational Flight Hardware is being checked out simultaneously during site activation.

Activation and modification/installation costs include a contingency factor to incorporate unidentified modification effort.

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**1.0 DEFINITIONS OF COST ELEMENTS****1.1 LABOR COST**

Cost of the Direct Labor expended to perform the various tasks defined in the study.

**1.2 RAW MATERIAL AND PURCHASED PARTS**

The cost for procured material including crating and shipping costs, and other vendor charges for special handling or expedited delivery schedule.

**1.3 PROCURED SERVICES**

The cost for Procured Services such as the testing of special components are assumed to be Government-furnished.

**1.4 FRINGE BENEFITS**

Fringe Benefits represent employee benefits such as Retirement, FICA., Vacations, Holidays, Sick Leave, Leave With Pay, Group Insurance, Union Pensions, Voluntary Savings Plans and Severance Pay, Taxes, Workmen's Compensation and Unemployment Insurance.

**1.5 OTHER DIRECT LABOR COSTS**

- a. Materials and Supplies - includes the cost of reproduction and administrative supplies
- b. Travel and Subsistence - represents the cost of normal business trips
- c. Relocation - the cost of acquiring new employees or of relocating employees from another geographical area
- d. Other miscellaneous charges

**1.6 ADMINISTRATIVE**

Administrative costs reflect the expenses generated in support of the overall business base. Included are costs incurred by group functional executives and new business expenses.

**1.7 OVERHEAD**

Overhead is applied to total Direct Labor hours, representing the cost of indirect salaries and wages, and such non-labor costs as building lease, telephone and telegraph, equipment lease and rentals, and miscellaneous.

**2.0 LABOR RATE SUPPORT**

All labor rates have been constructed so as to be representative of an industry average, and incorporate a necessary skill mix commensurate with task requirements.

Three basic rates were estimated to be applicable to the major areas of labor:

Design	\$ 12.99/Hour
Construction/Modification	\$ 12.00/Hour
Activation	\$ 11.83/Hour

In the following sections each of these rates is broken down in detail to its component factors.

#### 2.1 DESIGN LABOR RATE SUPPORT

The data and details contained in the Design Labor Rate presents combined costs which include direct Management, Technical and Administrative functions, and a composite skill mix of designers, draftsmen and other associated engineering skills.

This rate was developed from the average costs per Engineer hour from historical and empirical data available to Boeing Atlantic Test Center.

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	<u>Rate Per Hour</u>
Engineering Labor Rate (Including Fringe Benefits)	\$ 8.55
Other Direct Costs	.22
Overhead	<u>1.56</u>
Sub-total	\$10.33
General & Administrative (16.5% of Sub-total Cost)	<u>1.70</u>
Total Cost	12.03
Fee @ 8%	<u>.96</u>
Composite Rate	<u><u>\$12.99</u></u>

#### 2.2 MODIFICATION/INSTALLATION CRAFT LABOR RATE

The Craft Labor Rate presents combined costs for composite crew loading, field fabrication and erection labor, minor erection equipment, fringe benefits, home office costs including purchasing, and all other overhead and profit. These data were estimated from information extrapolated from the

project stabilization agreement for Cape Kennedy, Patrick Air Force Base, and Kennedy Space Center, and the Commercial Industrial Engineering & Estimating Standards for 1968 published by Richardson Engineering Service.

	<u>% Of One Hour</u>	<u>Rate/Hour Including F/B</u>	<u>Labor Cost/ Hour</u>
Foreman	10.0%	\$6.34	\$ .63
Field Engineer	5.0%	\$6.24	\$ .31
J Journeyman	<u>85.0%</u>	<u>\$5.79</u>	<u>\$4.92</u>
	100.0%	x	\$5.86
Overhead:			<u>% of Labor</u>
Unemployment Insurance, Workmen's Compensation, Social Security and Liability Insurance			15%
Temporary Construction and Job Cleanup			10%
Small Tools, Consumables and Minor Erections			12%
Field Supervision other than Job Foreman included in Field Crew			12%
Home Office Costs including Estimating, Purchasing, Administrative, Bonds, and all other costs			11%
Erection Equipment			20%
Total			<u>80%</u>
Total Cost (Composite Field Crew Hour):			
One Hour @ \$5.86			\$ 5.86
Overhead @ 80%			4.69
Hazard Pay (1/2 Labor Hour @ 50¢ Per Hour)			.25
Daily Travel Pay (\$3.50 for each 8 Journeyman/ Hours)			.37
Sub-total			\$11.17
Fee @ 7%			.78
Total			\$11.95
Use			\$12.00

### 2.3 ACTIVATION LABOR RATE SUPPORT

The data and details contained in the Activation Engineering Labor Rate presents combined costs including Direct Management, Technical and Administrative costs, a composite skill mix of designers, draftsmen and other support functions such as Systems Test, Developmental, Quality Control and Materiel.

This rate was developed from the average costs per engineering and support organization hours from historical and empirical data available to Boeing Atlantic Test Center.

Labor Rate (Including Fringe Benefits)	\$ 7.64
Other Direct Costs	.20
Overhead	<u>1.56</u>
Sub-total	\$ 9.40
General & Administrative (16.5% of Sub-total Cost)	<u>1.55</u>
Total Cost	\$10.95
Fee @ 8%	<u>.88</u>
Composite Rate	<u>\$11.83</u>

	Rate Including Fringe Benefits	Estimated % of Effort	Composite Rate
Engineering	\$8.55	16.4%	\$ 1.40
Systems Test	9.07	23.0%	2.09
Developmental	6.86	29.7%	2.04
Quality Control	6.93	26.8%	1.86
Materiel & Facilities	5.98	4.1%	<u>.25</u>
			<u>\$ 7.64</u>

### 3.0 DEVELOPMENT OF DESIGN ENGINEERING MANHOURS

Total Engineering Hours were developed using Engineering Design Hours as the base from which other Engineering functions were factored. That is, cost relationships were developed which represent the relationship of Systems Engineering, Reliability Engineering, Logistics, etc., to the design effort.

Although complete data for all Apollo contractors were unavailable, data from Saturn V experience are assumed to be representative for this type of effort. The following Design relationship assumptions were used:

<u>LINE</u>	<u>FACTOR APPLICATION</u>	
1. Design Engineering	Base	*100.0
2. Design Liaison	10% x Base	= 10.0
3. Checking & Release	15% x Design Engr. & Design Liaison	= 16.5
4. Total Design	Line 1 + 2 + 3	= 126.5
5. Systems Engineering	16% x Total Design	= 20.2
6. Reliability Engineering	11% x Design Engr. (Line 1)	= 11.0
7. Configuration Management	3% x Total Design	= <u>3.8</u>
	Total	161.5
	Use	<u>162.0</u>

\* Theoretical Base = 100.0 Hours

Total Engineering                    162.0% of Line 1

#### 4.0 MANPOWER DEFINITION

The manpower required to perform the various functions relative to the J-2S Improvement Study is defined within the major classifications of Design, Construction/Modification, and Activation. Further definitions of these classifications are given in the subsequent paragraphs.

##### 4.1 DESIGN

###### 4.1.1 ENGINEERING

###### 4.1.1.1 SYSTEMS ENGINEERING

Provide Systems Analysis, Design Criteria, CEI Specifications, Systems Optimization, Systems Definition, Trade Studies.

**4.1.1.2 DESIGN ENGINEERING**

Provide Designs, Drawings and Documentation and related Liaison Support necessary to procure Materials, Fabricate, Construct and Checkout a specified Design Concept.

**4.1.1.3 RELIABILITY ENGINEERING**

Provide various Reliability Reviews and analysis of Designs and Design Concepts.

**4.1.1.4 LOGISTICS**

Provide Operation and Maintenance Analysis and provide and control spares as required.

**4.1.1.5 CONFIGURATION MANAGEMENT**

Develop Configuration Management Plan.

**4.1.2 MATERIEL**

Provide Materiel Support to Engineering

**4.1.3 FACILITIES**

Provide Space and Equipment and services not furnished by the Government.

**4.1.4 OTHER DIRECT COSTS**

Training, Materials and Supplies, Overhead, etc.

**4.2 MODIFICATION/INSTALLATION****4.2.1 PROCUREMENT**

Provide labor to procure, receive, store and control materials, parts and services needed to implement the selected design.

**4.2.2 CONSTRUCTION**

Provide labor for Fabrication, Erection, Functional Testing and Quality Surveillance associated with implementing the design.

**4.2.3 MATERIAL COST**

Raw Material, Parts and Services procured in support of construction.

**4.2.4 FACILITIES**

Provide space, equipment and services not furnished by the Government which are needed to support construction activity.

**4.2.5 OTHER DIRECT COSTS**

Training, Material and Supplies, Overhead, etc.

**4.3 ACTIVATION****4.3.1 ENGINEERING****4.3.1.1 DESIGN**

Provide Continuing Engineering to sustain the design and "make operable" modifications required in the Activation Phase.

**4.3.1.2 SYSTEMS ENGINEERING**

Provide Systems Engineering analysis and related supporting functions through the Activation Phase.

**4.3.1.3 RELIABILITY**

Provide continued Reliability analysis, Criticality Number determination and related reliability functions in support of Activation and Modification.

**4.3.1.4 LOGISTICS**

Provide Logistics Support for Spare Parts provisioning and writing and revising Operations and Maintenance Manuals.

**4.3.1.5 CONFIGURATION MANAGEMENT**

Provide Configuration Management, control and reporting for all facilities and Contract End Items through activation of the Launch Complex.

**4.3.1.6 PROGRAM MANAGEMENT AND CONTROL**

Provide program scheduling, reporting and control functions related to the program goals and milestones established for the implementation of this program.

**4.3.2 SYSTEMS TEST**

Provides test engineering support for preparing Test Procedures, conducting the test program, and surveillance of operation and modification of equipment.

**4.3.3 DEVELOPMENTAL**

Provide Technicians and labor in support of Testing, Modifications, Operation and Maintenance of the Launch Complex equipment.

**4.3.4 QUALITY CONTROL**

Provide Quality Control support for Quality Control Engineering, Planning and Inspection of Launch Complex equipment, and documentation.

**4.3.5 MATERIEL**

Provide Materiel support for Procurement, Receiving, Storage and Inventory Control of all Raw Materials, Parts and Services required for the Activation Phase.

USE FOR TYPEWRITTEN MATERIAL ONLY

## OPERATIONS - DELTA PROCEDURES DATA

Procedure No.	Base Line - 503 Vehicle			S-II With One Restart - No LEO			S-IVB With 1 or 2 Restarts - S-II With No Restart (LR)		
	Operations			Implementation Chg. Proced			Implementation Chg. Proced		
	No. of Men/	Hrs./	Procedure	Total Hrs./	Hrs./	% of Chg. to	Total Hrs./	Hrs. (or -) To	Delta Hrs./
V28C75	NA	16	6	96	-0-	-0-	96	-0-	-0-
V28133	NA	3	1	3	-0-	-0-	3	-0-	-0-
SIVB135	NA	7	1	7	-0-	-0-	7	-0-	-0-
SIVB136	NA	5	1	5	-0-	-0-	5	-0-	-0-
V28144	NA	13	40	520	-0-	-0-	520	-0-	-0-
V28145	NA	6	40	240	-0-	-0-	240	-0-	-0-
V28178	D	6	40	240	-0-	-0-	80	-0-	-240
0129017	D	3	6	18	-0-	-0-	15	+ 25	+ 23
0129026	D	4	8	32	-0-	-0-	8	-100	-100
0129022	NA	6	44	264	-0-	-0-	-264	-0-	-264
0129013	NA	3	3	9	* 50	-100	-264	-0-	-264
V29C24	NA	3	1	3	* 40	-10	8	-10	-1
V29C38	NA	3	2	6	* 20	-10	5	-10	-1
0129032	NA	3	4	12	* 10	-12	-12	-0-	-0-
V29C37	D	2	2	4	-0-	-0-	30	-0-	-4
V29C55	D	10	20	200	-0-	-0-	200	-0-	-200
0129056	D	3	6	18	-0-	-0-	5	-100	-100
0129213	D	6	6	36	-0-	-0-	8	-100	-100
V29539	D	6	40	240	-0-	-0-	80	-0-	-240
V29C14	B	38	16	608	-0-	-0-	608	-0-	-608
V29C15	D	20	17	340	-0-	-0-	340	-0-	-340
0139000	D	3	4	12	-0-	-0-	12	-0-	-12
0139002	D	3	4	12	-0-	-0-	12	-0-	-12
0139003	D	3	6	18	-0-	-0-	18	-0-	-18
Install Eng. Start Ord.	D	6	40	240	-0-	-0-	240	-0-	-240
E/O Eng. Start Ord.	D	6	40	240	-0-	-0-	240	-0-	-240
Initiator	D	6	40	240	-0-	-0-	240	-0-	-240
Grand Total Less Douglas		58,164	2,769	20,985	-2,238	-4,333	54,612	-3,552	
Grand Total Less Boeing		23,223	-	-	-	-	-	-	

NA - North American  
 B - Boeing  
 D - Douglas  
 IBM - International Business Machines

\*S-II 1,211 + \*62% = 1,962 \*12.99/Hr. = \$25,486  
 Mission Fecular  
 \*S-II 4,558 + 62% = 2,564 \*12.99/Hr. = \$32,787  
 2,769 4,333 7,019

\*These changes would be required if not previously accomplished for a LOR Mission

\*S-II -1,410 + \*62% = 2,284 \*12.99/Hr. = \$29,113  
 S-IVB -2,922 + 62% = 1,735 \*12.99/Hr. = \$21,122

Sheet F-13

## OPERATIONS - DELTA PROCEDURES DATA

Procedure No.	Base Line - 503 Vehicle			S-II With One Restart - No S-IVB Stage LEO			S-IVB With 1 or 2 Restarts - S-II With No Restart - (LQR)				
	Operations			Implementation Chg. Procd			Implementation Chg. Procd				
	No. of Men/Procedure	Hrs./Procedure	Total Hrs./Procedure	Hrs. to Chg. to Base Line	% of Chg. to Base Line	Total Hrs. Procedure	Hrs. to Chg. to Base Line	% of Chg. to Base Line	Total Hrs. Procedure	Hrs. to Chg. to Base Line	% of Chg. to Base Line
V24243	NA	3	16	48	-0-	48	-0-	-0-	48	-0-	-0-
V24253	NA	3	80	* 240	* 80	- 20	- 20	* 80	- 20	- 20	- 20
V24254	NA	10	72	* 720	* 40	- 40	- 40	* 576	- 144	- 576	- 144
OV24255	NA	4	40	* 160	* 40	- 10	- 10	* 144	- 36	* 144	- 36
V24258	NA	3	30	* 90	* 0-	- 10	- 10	* 40	- 10	* 40	- 10
V24266 (New Procd Req'd)	D	4	60	* 240	* 173	+ 100	+ 100	* 81	- 9	* 81	- 9
OV24272	T	3	8	* 24	* 173	+ 240	+ 240	* 240	- 24	* 240	- 24
OV24273	L	2	1	* 2	* 2	-0-	-0-	* 2	-0-	* 2	-0-
SV24311	MA	3	8	* 24	* 20	-0-	-0-	* 24	-0-	* 24	-0-
OV24339	MA	3	40	* 120	* 40	-0-	-0-	* 120	-0-	* 120	-0-
V24344	D	4	20	* 80	* 16	-5	-5	* 80	-0-	* 80	-0-
V25194	NA	9	120	* 1,080	* 40	-0-	-0-	* 1,026	- 54	* 1,026	- 54
V25196	NA	3	16	* 48	* 40	-0-	-0-	* 48	- 12	* 48	- 12
V25309	NA	3	16	* 48	* 20	+ 15	+ 15	* 55	+ 7	* 55	+ 7
OV24311	MA	10	4	* 40	* 0-	-0-	-0-	* 40	-0-	* 40	-0-
OV24385	MA	16	4	* 64	* 16	+ 5	+ 5	* 67	+ 3	* 67	+ 3
V266.2	D	4	200	* 800	-	-	-	-	-	-	-
SV266.03	D	4	40	* 160	* 20	-0-	-0-	* 20	-0-	* 20	-0-
OV26336	MA	3	8	* 24	* 20	-0-	-0-	* 24	-0-	* 24	-0-
OV26337	NA	2	2	* 4	* 0-	-0-	-0-	* 4	-0-	* 4	-0-
OV26348	NA	4	21	* 84	* 10	+ 25	+ 25	* 105	+ 21	* 105	+ 21
OV26350	NA	6	40	* 240	* 16	-0-	-0-	* 240	- 0-	* 240	- 0-
OV26411	NA	4	32	* 128	* 16	- 3	- 3	* 124	- 3	* 124	- 3
V27046	D	4	40	* 160	-	-	-	-	-	-	-
V27104	D	6	4	* 24	* 20	-0-	-0-	* 24	-0-	* 24	-0-
V27105	D	32	640	* 20,480	-	-	-	-	-	-	-
V27111	MA	9	1	* 9	* 16	-0-	-0-	* 9	-0-	* 9	-0-
V27115	NA	13	40	* 520	* 8	+ 2	+ 2	* 52	+ 8	* 52	+ 8
V27116	NA	8	1	* 8	* 16	-0-	-0-	* 8	-0-	* 8	-0-
V27117	NA	14	5	* 70	* 0-	-0-	-0-	* 70	-0-	* 70	-0-
V27118	NA	6	48	* 288	* 40	-100	-100	* 288	- 0-	* 288	- 0-
V27145	D	5	6	* 30	* 10	-0-	-0-	* 30	-0-	* 30	-0-
V27148	NA	10	60	* 600	* 40	+ 5	+ 5	* 630	+ 30	* 630	+ 30
SV27149	NA	12	15	* 180	* 40	-0-	-0-	* 180	- 0-	* 180	- 0-
V27154	NA	2	1	* 2	* 16	-0-	-0-	* 2	-0-	* 2	-0-
V27183	NA	2	1	* 2	* 20	+ 5	+ 5	* 2	-0-	* 2	-0-
V27191	D	6	4	* 24	* 10	-0-	-0-	* 24	-0-	* 24	-0-
V27197	NA	22	6	* 132	* 10	-0-	-0-	* 132	- 0-	* 132	- 0-
V28273	NA	13	40	* 520	* 0-	-0-	-0-	* 520	- 0-	* 520	- 0-
V28274	NA	13	3	* 39	* 0-	-0-	-0-	* 39	- 0-	* 39	- 0-

NA - North American

B - Boeing

D - Douglas

IBM - International Business Machines

## OPERATIONS - DELTA PROCEDURES DATA

Procedure No.	Vehicle Line - 503 Vehicle	S-II With One Restart - No S-IVB Stage				S-IVB With 1 cr : Restarts - S-II With No Restarts (LOR)			
		Implementation Chg. Proc'd		Operations		Implementation Chg. Proc'd		Operations	
		No. of Men/ Procedure	Total Hrs./ Procedure	Hrs. to Chg. Procedure	% of Chg. to Base Line	Total Hrs./ Procedure	(+ or -) To Base Line	Hrs. to Chg. Procedure	Total Hrs./ Procedure
V21268	D	6	16	96	32	40	-	2	94
V21269	D	2	16	32	6	40	-	10	29
V21313 (New Proc'd Req'd)	D	3	2	6	173	+ 100	+ 6	- 5	6
V21346	D	2	1	2	2,400	-0-	-0-	- 0-	2
V21347	IBM	20	120	2,400	-0-	240	-0-	- 0-	20
V21349	IBM	6	40	2,400	-0-	24	-0-	- 0-	40
V21375	L	4	1	4	24	-0-	-0-	- 0-	24
V21371	IBM	6	4	24	-0-	24	-0-	- 0-	24
V21377	D	3	8	8	8	-0-	-0-	- 0-	8
V21378	D	2	4	8	32	* 24	-0-	- 0-	7
V2138C	D	4	8	32	21	* 173	+ 100	* 24	21
V23116	NA	7	3	6	21	* 24	-0-	- 0-	6
V23137 (New Proc'd Req'd)	D	3	2	6	21	* 173	+ 100	* 24	21
V23142	D	6	40	240	-0-	24	+ 12	-0-	240
V23175	IBM	3	4	12	16	+ 100	-0-	- 0-	12
0V24078	D	2	8	16	72	-0-	-0-	- 0-	16
V24083	D	3	24	72	1,600	-0-	-0-	- 0-	65
V24093	D	4	400	1,600	1,600	-0-	-0-	- 0-	1,360
V24091	D	2	8	16	160	173	+ 100	- 0-	15
V24092 (New Proc'd Req'd)	D	4	40	160	320	+ 160	- 0-	- 0-	157
SV24095	D	2	1	2	12,000	-0-	-0-	- 0-	2
V24098	D	3	32	96	6	10	+ 10	- 0-	10
V24104	D	4	12	48	480	* 20	- 15	- 0-	6
SV24107	D	4	12	48	15	* 45	- 0-	- 0-	48
V24116	NA	6	40	240	** 40	- 20	- 10	- 2	47
V24117	NA	20	600	12,000	- 15	192	* 40	- 20	192
0V24119	NA	3	2	6	-0-	10,200	-1,800	- 0-	10,200
V24124	NA	4	120	480	* 20	- 15	- 72	* 20	- 72
V24125	NA	3	15	45	* 50	- 0-	- 50	- 0-	45
V24160	NA	8	4	32	* 16	+ 8	* 3	* 16	32
0V24184 (New Proc'd Req'd)	D	2	2	4	173	+ 100	8	+ 4	173
V24212	D	2	10	20	20	-0-	-0-	- 0-	4
V24213	D	4	16	64	173	+ 100	-0-	- 0-	20
V24217 (New Proc'd Req'd)	D	4	16	64	64	-0-	-0-	- 0-	64
V24238	NA	4	16	64	173	+ 100	-0-	- 0-	64
V24243	NA	4	60	240	* 20	+ 25	300	+ 60	5
V24244	NA	20	5	100	8	* 6	-0-	- 0-	100
V24245	NA	24	2	48	128	-0-	-0-	- 0-	48
V24246	NA	4	32	128	-0-	-0-	- 0-	- 0-	128
V24247	NA	3	16	48	-0-	-0-	- 0-	- 0-	48

'IA - North America.

B - Boeing

D - Douglas

IBM - International Business Machines

## OPERATIONS - DELTA PROCEDURES DATA

Procedure No.	No. of Men/ Procedure	Base Line - 503 Vehicle		S-II With One Restart - No S-IVB Start (LBO)		S-IVB With 1 or 2 Restarts - S-II With No Restart (LOR)	
		Operations		Implementation Chg. Proced		Operations	
		Hrs. / Procedure	Total Hrs. Procedure	Hrs. to Chg. Procedure	% of Chg. to Base Line	Hrs. to Chg. Procedure	Total Hrs. Procedure
V200G4	NA	6	8	48	*	80	+ 30
V200I0	E	6	13	78	*	80	- 10
V200I7	B	6	16	96	*	40	- 5
V200J7	B	6	15	90	*	16	- 0-
V200J8	D	6	96	576	-	90	- 0-
V200J9	B	16	640	*	80	- 10	-
V201E0	D	24	173	4,152	-	576	- 64
V21C28	D	6	8	48	-	36	- 0-
V21C65	MA	6	6	36	- 0-	32	- 0-
V21C77	D	4	4	16	- 0-	32	- 0-
V21C78	NA	4	8	32	- 0-	16	- 0-
V21C79	NA	4	8	32	*	16	- 0-
V21073	D	6	8	48	*	1	+ 1
V21083 (New Proced Req'd)	(D)	2	3	6	*	173	-
V21086	D	3	1	3	-	12	+ 6
V211C1	NA	6	8	48	-	48	- 0-
V211C3	NA	3	8	24	*	16	- 0-
V211C4	NA	4	1	4	*	40	- 0-
V211C5	NA	3	2	6	*	40	- 0-
V211C7	NA	6	4	24	*	8	- 0-
V211C9	NA	2	8	16	*	20	- 0-
V21110	NA	6	24	144	*	20	- 0-
V21111	NA	4	1	4	*	158	- 0-
V21112	NA	3	8	24	*	6	- 0-
V21113	NA	2	1	6	*	24	- 0-
V21228	D	4	2	8	*	2	- 0-
V21228	IBM	2	12	24	*	18	- 0-
V21248	IBM	3	6	18	*	12	- 0-
V21249	IBM	3	4	12	*	12	- 0-
0V21251	NA	5	40	200	*	20	- 0-
V21254	IBM	6	16	96	*	96	- 0-
V21257	D	10	48	480	-	60	-
V21259	D	6	40	240	-	80	-
V21260	D	8	32	256	-	50	-
V21261	D	10	32	320	-	80	-
V21263	D	6	12	72	-	55	-
V21264	D	3	8	24	-	20	-
V21265	D	3	4	12	-	12	-
V21267	D	8	54	432	-	40	-

NA - North American

B - Boeing

D - Douglas

IBM - International Business Machines

**LIMITATIONS**

This document is controlled by 5-8768

All revisions to this document shall be approved by the  
above noted organization prior to release.

## ACTIVE SHEET RECORD

SHEET NUMBER	REV LTR	ADDED SHEETS				SHEET NUMBER	REV LTR	ADDED SHEETS			
		SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR			SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR
1	A					41					
2						42					
3						43					
4						44					
5						45					
6						46					
7						47					
8						48					
9						49					
10						50					
11						51					
12						52					
13	A					53					
14						54					
15						55					
16						56					
17						57					
18						58					
19						59					
20						60					
21						61					
22						62					
23						63					
24						64					
25						65					
26						66					
27						67					
28						68					
29						69					
30						70					
31						71					
32						72					
33						73					
34						74					
35						75					
36						76					
37						77					
38						78					
39						79					
40						80					

## ACTIVE SHEET RECORD

SHEET NUMBER	REV LTR	ADDED SHEETS				SHEET NUMBER	REV LTR	ADDED SHEETS			
		SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR			SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR
81						A-3					
82						A-4					
83						A-5					
84						A-6					
85						A=7					
86						B-1					
87						B-2					
88						B-3					
89						B-4					
90						C-1					
91						C-2					
92						C-3					
93						C-4					
94						C-5					
95						C-6					
96						C-7					
97						C-8					
98						C-9					
99						C-10					
100						C-11					
101						C-12					
102						C-13					
103						C-14					
104						C-15					
105						C-16					
106						C-17					
107						C-18					
108						D-1					
109						D-2					
110						D-3					
111						D-4					
112						D-5					
113						D-6					
114						D-7					
115						D-8					
116						D-9					
117						D-10					
118						D-11					
A-1						D-12					
A-2	A					D-13					

## ACTIVE SHEET RECORD

SHEET NUMBER	REV LTR	ADDED SHEETS				SHEET NUMBER	REV LTR	ADDED SHEETS			
		SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR			SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR
D-14						E-8					
D-15						E-9					
D-16						E-10					
D-17						F-1					
D-18						F-2					
D-19						F-3					
D-20						F-4					
D-21						F-5					
D-22						F-6					
D-23						F-7					
D-24						F-8					
D-25						F-9					
D-26						F-10					
D-27						F-11					
D-28						F-12					
D-29						F-13					
D-30						F-14					
D-31						F-15					
D-32						F-16					
D-33						1001					
D-34						1002	A				
D-35						1003	A				
D-36						1004	A				
D-37						1005	A				
D-38											
D-39											
D-40											
D-41											
D-42											
D-43											
D-44											
D-45											
D-46											
E-1											
E-2											
E-3											
E-4											
E-5											
E-6											
E-7											

## REVISIONS

LTR	DESCRIPTION	DATE	APPROVAL
	Original Release	2-28-69 Doc. Control 2-28-9 m B	
A	To add Section 10, Retrofit, and to revise Section 3 to include Retrofit Summary	3-13-69 JL for P.D.M. Doc. Control 3-13-9 m B	